TOCKLAI EXPERIMENTAL STATION

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ANNUAL SCIENTIFIC REPORT 1972-73

TEA RESEARCH ASSOCIATION, CALCUTTA

OUR COVER

A new clone for Tea Industry — TV 19 is high yielding as TV 18 but combines yields with cup characters.

TEA RESEARCH ASSOCIATION

Annual Scientific Report

(1st April 1972 to 31st March 1973)

Published by
TOCKLAI EXPERIMENTAL STATION
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Contents

Director's Report

(1st April 1972 to 31st March 1973)

ORGANISATION

On the 31st March 1973, the Senior Staff consisted of :- -

Directorate :

Director
N. K. Jain, M.Sc., Ag. (B.H.U.), Ph.D. (Illinois)

Administrative & Finance Controller
J. Tessier-Yandell, M.I.I.P.M., A.M.I.P.M., A.M.B.I.M.

Accounts :

Accounts Officer
S. Mazumdar, B.Com. (Cal.), A.C.A.

Maintenance :

Station Engineer
G. B. Singh, A.M.I.S.E.

Medical :

Medical Officer
Dr. (Major) S. W. Rohman, M.B.B.S.

Library & Publications Department :

In-charge
J. N. Sharma, M.A. (Gau.)

Soils & Meteorology Department :

Soil Scientist
S. K. Dey, B.Sc. (Cal.), Assoc. I.A.R.I.

Senior Scientific Assistants
N. G. Bhattacharyya, B.Sc. (Cal.)
A. K. Sengupta, B.Sc. (Cal.)

Botany Department :

Senior Botanist
D. N. Barua, B.Sc. (Cal.), Ph.D. (Cantab).

Plant Physiologist
W. Hadfield, B.Sc. Hon. (Liv).

Plant Breeder
H. P. Bezbaruah, M.Sc., Ph.D (Gau.)

Senior Scientific Assistants
K. N. Dutta
B. N. Gogoi, B.Sc. (Gau.)

Agriculture Department :

Agronomist
F. Rahman, M.Sc., Ag. (Bihar), Ph.D. (I.A.R.I.)

Second Agronomist
B. C. Phukan, B.Sc., Ag. (Gau.), A.I.F.C.

Manager, Borbhetta Experimental Estate
H. N. Sarma, B.Sc. (Cal.)

Entomology Department :

Entomologist
B. Banerjee, M.Sc. (Cal.), M.S. (S. Illin.), Ph.D. (London), F.A.Z., F.R.E.S. (London).

Senior Scientific Assistant
N. Sengupta, B.Sc. Ag. (Cal).

Mycology Department :

Mycologist
G. Satyanarayana, B.Sc., Hon. (Andhra), Ph.D. (Mad.), F.B.S.

Biochemistry Department :

In-Charge
S. Chakraborty, M.Sc., Ph.D. (Cal.)

Tea Tasting Department :
Tea Taster
R. P. Basu

Third Tea Taster
A. K. Das, B.A. (Gau.)

Second Tea Taster, *West Bengal*
S. Sen, B.Sc., (Cal.)

Engineering Research & Development Department :
Senior Research Engineer
D. N. Barbora, B.Sc., Mining (B.H.U.) M.Sc. Eng. (London), D.I.C., M.I.Ag.E.

Second Research Engineer
T. C. Barua, B.Sc. Hons. (Gau.), B.Sc. Mech. Eng. (B.H.U.), M.Sc. Mech. Eng. (Man.)

Statistics Department :
Statistician
A. K. Biswas, M.Sc. (Gau.)

Advisory Department :
Chief Advisory Officer
W. J. Grice, M.A., Dip. Ag. (Cantab)

Senior Advisory Officer
P. C. Sharma, M.Sc., (B.H.U.), Ph.D. (London), F.L.S.

Advisory Officer, *Upper Assam*
T. K. Ghosh, B.Sc., Ag. (Pat.), Ph.D. (Cornell), Assoc. I.A.R.I.

Advisory Officer, *Lower Assam*
B. Barthakur, M.Sc. Ag. (Gau.)

Advisory Officer, *North Bank*
H. Mitra, B.Sc. (Cal.)

Advisory Officer, *Cachar*
J. Chakravartee M.Sc. Ag. (Gau.)

Advisory Officer, *West Bengal*
S. Basu, B.Sc. Ag. (Delhi), Assoc. I.A.R.I.

Advisory Officer, *Dooars & Terai*
B. C. Barbora, M.Sc. Ag. (I.A.R.I.)

Advisory Officer, *Darjeeling*
S. K. Sarkar, B.Sc. (Cal.), B.Sc. Ag. (B.H.U.)

SENIOR STAFF MATTERS

(a) **Appointment**

Dr. N. K. Jain, Deputy Director appointed as Director of the Station on 1st October, 1972. Mr. J. Tessier-Yandell was transferred as the administrative & Finance Controller of the Station with effect from 29th September, 1972. Mr. B. C. Phukan joined as Second Agronomist from 1st August, 1972.

(b) **Retirement**

Mr. S. K. Dutta left Tocklai on 1st October, 1972 for leave preparatory to retirement.

Mr. M. K. Choudhuri left the Station on 29th September 1972 on transfer as Secretary, S.V.B.I.T.A.

TRAINEE

In addition to four C.S.I.R. Junior Research fellows working in the Station, two batches of nine and eight employees respectively from Member estates completed three months training in Vegetative Propagation.

LECTURE COURSES

The following lecture courses were held during the year :—

1. **Agricultural Chemicals Course (1972)**
1st Course from 11. 9. 72 to 13. 9. 72—26 planters attended.

2nd Course from 18. 9.72 to 20. 9. 72—33 planters attended.

2. **Surveying and Drainage Course (1972)** for Govt. Approved Estate surveyors from 20.11.72 to 22. 11. 72—10 people attended.

Surveying and Drainage Course for Planters

1st Course from 27. 11. 72 to 1. 12. 72— 23 planters attended.

2nd Course from 4. 12. 72 to 8. 12. 72—20 planters attended.

3rd Course from 11. 12. 72 to 15. 12. 72— 26 planters attended.

VISITORS

Some of the visitors in addition to local planters are listed below :—

Ahmed Moradi Haghgo and Ali Imampour—Lahijan Tea Organisation, Iran.
M. K. Mukherjee—Joint Secretary, Ministry of Agriculture, New Delhi.
K. Kuramoto Unico International Cop., Tokyo, Japan.
Judith Evanson River Forest, Illinois, U.S.A.
Sir Terence Garvey—British High Commissioner in India and Lady Garvey
F. Stephen Miles British Deputy High Commissioner, Calcutta.
H. Ferguson James Finlay & Co., Glasgow.
David E. Barnes—Ansul, Michigan, U.S.A.
M. S. Swaminathan—Director General, I.C.A.R., New Delhi.
R. J. Isherwood, Cynamid International, Hongkong.
William C. Von Meyer Rohm & Has Co., U.S.A.
R. H. S. Fennell—World Bank—Washington, D.C. 20015, U.S.A.
T. B. How African Highland Produce Co., Ltd., Kericho, Kenya.
Rovert Evenson Economic Growth, Yale University, U. S. A.
V. A. Altekar—Director, National Metallurgical Laboratory, Jamshedpur-7.
A. Singh, —Director, Central Electronics Engineering Research Institute, Pilani, Rajasthan.
P. K. Jena—Director, Regional Research Laboratory, Bhubaneswar-4.
A. R. Verma,—Director, National Physical Laboratory, New Delhi-12.
S. R. Valluri—Director, National Aeronautical Laboratory, Bangalore-17.
Hari Narain—Director, National Geophysical Research Institute, Hyderabad-7.
H. V. K. Udupa—Director, Central Electro-Chemical Research Institute, Karaikudi-3.
K. Ray—C.S.I.R., New Delhi.
Dinesh Mohan—Director, Central Building Research Institute, Roorkee, U.P.
Bh. Subbaraju Director, Central Road Research Institute, New Delhi-20.
B. L. Amla Scientist In-charge, Central Food Technological Research Institute, Mysore-2.
S. H. Zaidi—Director, Industrial Toxicology Research Centre, Lucknow.
N. K. Panikkar Director, National Institute of Oceanography, Panaji, Goa.
G. S. Ramaswamy—Director, Structural Engineering Research Centre, Madras.
Joseph George—Director,Indian Plywood Industries Research Institute, Bangalore-22.
A. F. V. Krishnan—Jt. Secretary, Ministry of Finance, Government of India.
K. Sreenivasan—Director, South India Textile Research Association, Coimbatore-14.
T. Radhakrishnan Director, Indian Jute Industries' Research Association, Calcutta-53.
H. C. Visvesvaraya Director, Cement Research Institute of India, New Delhi-49.
S. Parthasarthy Scientist-in-charge,Indian National Scientific Documentation Centre, New Delhi-12.
Y. R. Chadha—Publication and Information Directorate, New Delhi-12.
S. K. Mangal Central Scientific Instruments Organisation, Chandigarh-20.
K. C. Krishnamurthi Secretary, Council of Scientific and Industrial Research, New Delhi.
G. J. Mohanrao Scientist In-charge Central Public Health Engineering Research Institute, Nagpur.
C. V. S. Ratnam—Managing Director, National Research Development Council.
K. P. Tripathi Former Minister of Industries, Assam.
C. K. Atal—Scientist In-charge,Regional Research Laboratory, Canal Road, Jammu.

B. C. Raychaudhuri--Central Mechanical Engineering Research Institute, Durgapur-9.
R. V. Sitholey—Scientist Incharge, National Botanic Gardens, Lucknow.
R. M. Chakrabarti—Director, Indian Institute of Experimental Medicine, Calcutta-32.
S. C. Dutta—Scientist in-charge Central Indian Medicinal Plants Organisation, Lucknow.
K. D. Sharma--Director, Central Glass & Ceramic Research Institute, Calcutta-32.
D. J. Mehta—Director, Central Salt and Marine Research Institute, Bhavnagar-32.
N. Ramanathan—Scientist In-charge Central Leather Research Institute, Madras-20.
M. G. Krishnan—Director, Indian Institute of Petroleum, Dehra Dun.
D. Tilak—Director, National Chemical Laboratory, Poona-8.
R. P. Sinha —Joint Secretary, Industries Department, Govt. of Meghalaya.
H. P. Gupta —Officer-in-Charge, Industrial Finance Corporation of India, Gauhati.
B.B.Lyngdoh—Minister Govt. of Meghalaya,Shillong.
W.I.T. de C. Wheeler --Deputy Chairman, Indian Tea Association, London and Director, Macneill & Barry Ltd.
J. C. Bakshi—Assoc. Director Research, Punjab Agricultural University Ludhiana.
S. K. Murthy—I. C. A. R., New Delhi.
G. L. Sharma--Principal cum-Joint Director, Indian Veterinary Research Institute, Bhatnagar, U. P.
S. H. Davies --London Scientific Committee Member and Director, Octavius Steel & Co., Ltd.
S. Ananthnarayan—Indian Plywood Industries Research Institute, Bangalore
V. J. Victor –Indian Plywood Industries Research Institute, Bangalore
C. G. Pickford—Member London Scientific Committee of Tea Research Association and Eastern Produce (Holdings) Ltd., London.
D. P. Motiramani --Director of Research Jawaharlal Nehru Agricultural University, Jabalpur.
W. Feldhem--Prof. Inst. of Human Nutrition, Giessen, Germany.
C. Gordon-Smith –Director, Moran Tea Co., Ltd., London.
Sir Patrick Shaw--Australian High Commissioner, New Delhi and Lady Shaw.
B. Zlataric—Commodities Division, FAO, Rome.
Daljit Singh—Director, (Hort) Ministry of Agriculture, Krishi Bhavan, New Delhi.

Advisory Department

GENERAL

During the year under review the Advisory Departments in Assam and West Bengal were combined into one Department to ensure unified advisory policies and planning and execution of experiments. Mr. W. J. Grice was transferred from West Bengal to Tocklai and Mr. B. C. Barbora from Tocklai to the Dooars. Mr. S. K. Sarkar was relieved of his responsibility for Terai in order to pay more attention to Darjeeling plantations.

The reorganisation was completed towards the end of 1972 and it already appears that the change has resulted in an overall improvement in our services for there has been a substantial increase in number of visits made to tea estates.

At each outstation plots are maintained from where cuttings and scions of Tocklai release clones are distributed to members. Some trials are also carried out in these plots. Also miniature factories are operating in the Dooars at Nagrakata and in Darjeeling at the Clonal Proving Station. Mr. S. Sen, Second Tea Taster, was transferred to the Dooars at the end of the period under review.

Visits

Advisory Officers who concentrate on touring made every effort to offer their services to every Member estate at least twice a year. The table below gives the breakdown of the visits made in each district.

District	No. of visits	No. of Member estates visited	No. of Member estates in the district
South Bank	270(210)	170(132)	243(245)
North Bank	199(202)	77(75)	83(86)
Cachar	88(85)	31(31)	35(36)
Dooars	161(162)	68(77)	82(92)
Terai	43(37)	20(17)	20(18)
Darjeeling including Sikim	96(82)	46(41)	50(47)
Total	857(778)	412(373)	513(524)

Figures in brackets are for 1971/72.

There were about 80 more visits made in the year under review than in the previous year. The district where the major improvement occurred was the South Bank : there were also minor increases in Darjeeling and the Terai.

A very satisfactory trend is that some 40 more Members made use of our services as compared to the previous year, in spite of a slight reduction in overall membership. An unsatisfactory situation can be seen on the South Bank where only 170 members out of a total of 243 made use of our services. It is anticipated, however, that the reorganisation and the change in the system of informing members of Advisory Officers' programmes will bring about an improvement in this respect.

In addition to the visits detailed above, advisory officers paid a total of 43 visits to experiments in West Bengal and the Clonal Proving Station in Darjeeling.

Apart from routine visits, a greater interest has been shown in group meetings. The open discussions that are arranged to coincide with Area Scientific Committee meetings were generally well attended and the introduction of seminars was also widely welcomed and were well supported.

Crop and Weather

In all districts the 1972 season started off well mainly due to the well distributed rainfall in the early part of the season. In Assam and Darjeeling, heavy rain during May and June resulted in a poor second flush and in many areas in the Dooars, Terai and Cachar, the promise of a good start was shattered by severe, unprecedented and widespread hailstorms which continued until mid May. The damage to one estate in the Terai was so severe that not a single leaf could be found on any tea bush anywhere on the estate and very few shade trees were left undamaged. However, 1972 was generally a good year and most estates finished the season ahead in crop.

TV. 1 bushes under pegging and low tipping at 9th months from planting in an Upper Assam Estate.

In all districts the monsoon finished early and rainfall over the period October to March was well below normal, with the possible exception of the Upper Assam area. This has resulted in severe drought conditions in drought prone areas. The western areas on both North and South Banks in Assam also suffered and, therefore, the 1973 season has not got off to a good start.

ADVISORY AND EXTENSION

The principal points arising from advisory work are discussed briefly below :

1. Soil management

(a) **Land Planning & Drainage**

Due to the increasing awareness amongst our Members in all areas on the importance of land planning and drainage, a great deal of Advisory Officers' time has been spent on helping estates over this important topic. It is, therefore, necessary to report individually the main problems faced in the different areas.

However, it may be mentioned that one of the factors common to many areas in holding back planting according to topography is the paucity of trained surveyors in some districts -Cachar being the area that suffers most in this respect.

(i) **South Bank :** A certain amount of land planning and topographical planting has been done, but the size and shape of main drains and outlet problems were the chief topics for advice. Where improvements in main drains were put into practice, immediate improvements were seen.

(ii) **North Bank :** Several estates have accurately translated the topographical plan in the field with great success. Estates on the North Bank are fortunate for they have good surveyors at hand. However, a mistake has been made by several estates in allowing the surveyors to make the drainage plan. This, as had been pointed out, is not the surveyor's job. The responsibility for planning drainage falls firmly on the manager's shoulders.

A mature tea section in Upper Assam under step-up plucking (10 cm | 10 cm) during light pruning year. A new plucking table is formed after step-up plucking during end July / early August.

(iii) **Cachar :** Contour planting is not new in Cachar and all *teela* areas are planted on the contour. However, the contour drains are nearly always blind and this leads to soil erosion in times of heavy rainfall due to the blind drains filling up and overflowing. Continual advice has been given to have shallow collector drains running down the natural depressions on teelas, with graded contour drains feeding into them.

Flats pose a very different problem and emphasis has been given on having deep perimeter drains at the base of teelas to check seepage water and also to explore the possibility of better outlets. One thing is certain that no amount of field draining in a waterlogged flat will improve the situation until a better outfall is found.

(iv) **Dooars & Terai :** Quite a number of estates in the Dooars have been replanting and extending areas using modern methods of land planning. We would, however, like to see more estates adopting these methods as a matter of routine, and we have assured all interested estates our help and co-operation in this matter. It is heartening to report that for the first time in the Terai one estate has started planting on the basis of a catchment plan.

We have emphasised that the object of catchment planning and contour drainage has not only to dispose of excess water during monsoon months but also to help in conserving water for the subsequent dry period. Thus for Dooars and Terai, where drought in the cold weather is the rule rather than an exception, a well laid-out drainage system will be of benefit.

Recovery after rejuvenation pruning at 45 cm from the ground in an Upper Assam Estate.

The importance of the main drain size being in accordance with the catchment area, soil type and rainfall, has been emphasised during visits to estates where culverts and bridges, which were not of adequate size to cope with the amount of drainage water, were washed away during the heavy rain in July 1972.

(v) **Darjeeling :** Due to the completely different topography in Darjeeling, topographical planning for the purpose of water and soil conservation is essential and advice on this has been given on a number of occasions.

(b) **Mulching**

Inspite of the problems associated with large scale mulching of young tea areas, our advice in this direction has been followed by the more progressive estates with good results. It has been stressed by us that mulching is essential for quick establishment of young tea, especially in drought-prone area. It is often not realised that from the point of view of moisture conservation, the time of mulching is most important. We have had to point out on many occasions that mulching must be completed when the soil profile is still fully moist which is usually by the end of October.

We continue to advise estates to grow mulching materials in waste lands and this advice is catching on slowly. Citronella grass is becoming popular but the yield of mulch is nothing like as high as that from Guatemala or Pusa Giant Hybrid Napier. *Mimosa invisa* is commonly used on the North Bank.

(c) **Cultivation and Weed Control**

The use of herbicides is becoming more and more popular in all areas and many estates have again extended the area under chemical weed control and some estates are now 100% on weedicides. This, however, is not common, but instances when 60-80% of the area are under weedicides is becoming more and more common. Estates who are lagging behind are being persuaded to intensify their chemical weed control programme, and it is a pleasure to report that the idea is gaining popularity in all tea areas of North East India.

Gramoxone is the most commonly used herbicide and many estates have had a set back to their weedicide programme due to its shortage. This has resulted in estates trying out more dilute solutions than recommended, which have worked to some extent but regrowth has been quicker. More often than not cocktails were employed using Gramoxone, 2,4-D, Dalapon and Karmex, depending on the weed flora. *Mikania* has been largely brought under control due to its extreme susceptibility to 2,4-D.

Chemical weed control had a side effect. In areas where herbicides have been applied for several years, resistant weeds like *Polygonum chinense* or *Polygonum perfoliatum* were becoming a problem. At present there are no herbicides that successfully kill these weeds: so removal by hand has been advised.

Manager Serispore and Soil Scientist discuss soil erosion problems. (Note drain full of silt)

Because of the difficulties in spraying during the heavy rainfall period from the middle of June to the middle of September we have repeatedly advised estates in Darjeeling and heavy rainfall areas to complete one or two rounds of spraying between April and the middle of June. We have also emphasised the need for spraying in autumn in order to prevent weeds competing for moisture during the cold weather as well.

2. **Pruning and Plucking**

(a) **Pruning Cycles**

The most common pruning cycle in all plains areas is a three-year cycle of prune-deep skiff-medium or light skiff. However, there is a tendency for pruning cycles to become longer with the result that a higher percentage of the lighter forms of skiff are introduced. It has been pointed out that this is likely to result in a drop in quality, lead to plucking problems early in the year and expose tea to the rigors of droughts.

It is possible that the change to 4 and 5-year cycles from a 3-year cycle is a direct result of the good yield obtained in 1972 from the unpruned and light skiffed areas which must be attributed to the good early rainfall in 1972. As has been mentioned earlier in this report, the start of 1973 was highlighted by a drought in most areas which resulted in the early yields from unpruned and light skiff teas being very much less than was anticipated.

We have continued to stress the fact that no one cycle will meet all the requirements. Therefore, the limitations must be taken into consideration when deciding on a pruning cycle.

In Darjeeling our advice has been that pruning cycles should be so adjusted as to get the maximum first and second flush crop. However, it has been stressed that the availability of labour during the peak season must be borne in mind when deciding on a cycle.

(b) **Plucking**

Many estates suffer considerable crop loss due to undue rise in the plucking table. This is more so when tea is left unpruned or given lighter forms of skiff.

Contour drains on a Cachar teela full of silt after heavy rain. Soil erosion is severe.

We have had also to remind some estates that change in plucking standards from say, 'coarse' to 'standard' or 'medium' can result in a significant loss in crop. It is really a matter of economics to decide whether better quality of leaf resulting from 'standard' or 'medium' plucking is a sufficient compensation for the loss in crop. Obviously this would vary from district to district and depending on the market conditions from year to year.

Step-up plucking in mature tea has been tried to a large extent in Assam and the Dooars and to a certain extent in Cachar, the Terai and Darjeeling, with generally satisfactory results. It has also been tried in all areas on medium pruned, cut-back and heavy pruned tea and the results have been encouraging. It has been our advice that step-up plucking in mature tea should only be tried in areas not prone to drought. Further-more, to get maximum benefit, the bushes should be healthy and also not too high.

(c) **Rejuvenation**

Many estates in all districts have made a start with rejuvenation of old tea and this has been one of the most common topics for discussion during advisory visits. The concept of rejuvenation has been generally accepted in Assam and the Dooars: the Cachar and Terai districts, however, have been slow to take up this practice.

It had been made clear that rejuvenation is not a substitute for uprooting and replanting but supplementary to it. It should be taken as one of the tools to improve the existing teas whose yield is being constrained by vacancies, poor drainage, inadequate shade, old age etc. We have pointed out that to get the maximum return from rejuvenation, intensive infilling and improvement in shade, drainage etc. are essential.

(d) **Young Tea**

The step-up system or low tipping method of bringing young tea into production has been followed in all areas. One big drawback observed in this system is a lack of proper frame development: the frame is rather high. With the advent of closer spacing a low frame meets the essential requirement of ground cover and gives more flexibility in a pruning cycle. We are now advising a modified step-up system where a frame forming prune at a low level is introduced 12 to 18 months after decentering. We have stressed the importance of establishing a permanent frame early in the life of young tea and that it is definitely a wrong policy to sacrifice permanent frame establishment at the expense of crop in the first 2-3 years.

3. **Planting**

(a) **Infilling**

Infilling is becoming almost routine in all areas, but very little progress has, in general, been made in Cachar, the Terai and Darjeeling. However, one estate in Darjeeling has infilled by the "seed at stake' method with good success. This is of course possible only where the young seedlings can be properly looked after. The crop increase obtained in an experiment on infilling is very encouraging and indicates how infilling can be used to bring about crop increase.

We are frequently asked to advise on the treatment of infills and we stress that the aim should be to treat the young plants so that they produce leaf quickly. Frequent low prunes in an attempt to make a spreading bush is a waste of time as the infills are smothered out due to competition from the surrounding mature bushes.

Cleft grafting, Makaibari T. E., Darjeeling.

(b) **Extension**

Although extension planting is most desirable, we have had to point out on a number of occasions that it is not economical to extend on land that is not suitable both physically and chemically and such land is better utilized for growing mulching crops or for fuel tree plantations.

(c) **Replanting**

Tea Board Statistics indicate that the pace of replanting is far below that desirable. We have had to point out on a number of occasions that there is no substitute for replanting and estates will have to continue uprooting and replanting on a routine measures for their survival and improvement.

4. **Propagation**

(a) **Seed**

We have recommended the use of only hardy stocks for planting when seed is being used. Stock 203 is very much in demand and in fact demand has surpassed supply. Several estates have started establishing seed baris of Stocks 449 and 450.

(b) **Vegetative propagation**

An increased activity on vegetative propagation has been recorded in all districts. In our advice on suitable clones for the plains, preference has been given to TV 1, TV 12, TV 14, TV 16, TV 17 and TV 18, all of which have shown drought resistant properties. TV 10 and TV 11 are good clones but should be planted where droughts are not common. It should be noted that TV 9 which has been by far the most popular clone in nearly all districts has not been included in the list because its performance in droughty areas has not been very encouraging. We now recommend that it should now be phased out.

The Tea Research Association has given interim certificates to three clones for use in Darjeeling following comprehensive trials at the Clonal Proving Station, Ging, but it is noted with concern that the demand for these clones has not been as much as was expected.

5. **Fertilizers**

(a) **Nitrogen**

The nitrogen levels applied in different tea areas more or less conformed to our standard recommendation. But split application, which is not recommended by us, continued to be popular with many estates. Foliar application of urea in mature tea is now an established practice. A few estates sprayed urea from the middle of September to the middle of November in pruned and deep skiffed sections and they claimed that it has boosted up the back end crop. We have stressed that foliar application of fertilizers is likely to be beneficial when nutrient uptake from the soil is limited by drought or waterlogging. Ground application of urea as an alternative to sulphate of ammonia has also been common. Many estates had to apply fertilizers late due to a shortage at the start of the season.

(b) **Potash**

In all areas of Assam, application of potash has usually been based on soil test reports and response from potash has been reported from most areas. In Bengal the experiments have indicated no benefit in terms of crop by applying potash at levels higher than the recommendations given in T. E. Serial No. 176, filed under D. I. and an Advisory Leaflet to this effect was published in September 1972. In spite of this a number of estates have been applying high levels of potash as a routine practice.

Frame of a 4 year old bush brought up by low tipping method.

(c) **Zinc**

Many estates adopted foliar application of zinc as Zinc sulphate at rates varying between 15 to 25 kg/ha. The response quoted has been variable. We have advised the use of zinc in replanted areas during the skiffed years, provided that response has been observed in test plots.

6. **Shade**

(a) **Temporary**

Advice on planting out of *Indigofera teysmanii* at closer spacings of 1.5 2.5 m in extensions and replanted areas in preference to green cropping continued. In unshaded mature sections this species was planted at an initial spacing of 3 m with the object of removing alternate plants whenever required. Closer spacing provides quick shade in such areas. It was emphasised that wherever this temporary shade was used, proper lopping or thinning out must be done, otherwise it could have a deleterious effect on tea due to overshading and competition for moisture in drought prone areas.

(b) **Permanent**

The necessity of maintaining the proper shade status so that it is neither too heavy nor too light was emphasised. It had also been explained that the need of shade is variable depending on climatic condition, elevation, kind of tea, soil etc. It was further stressed that proper care against pests and diseases, particularly of young plants, both in the nursery and in the field ensures a good stand of shade trees.

Some estates in Upper Assam and on the North Bank have completely removed shade. The long term effects have yet to be seen.

In heavily shaded areas we have recommended the lopping of lower branches rather than the removal of trees for the latter operation results in extensive damage to the tea bushes.

7. Pests & Diseases

(a) Pests & Disease Bulletins

These continued to be issued at regular intervals in all districts and reports suggest that they continue to be popular.

(b) Mites

Reports indicated that red spider attack in the year under review declined in the North Bank, Dooars and Terai districts, whereas it continued to be a major pest in all other areas. The incidence of other mites were never very serious except for some cases of purple mite on the North Bank and scarlet mite in Cachar, Dooars and Terai. Darjeeling had its usual attack of red spider and scarlet mite particularly on estates where control measures are poor.

(c) Other pests

Incidence of looper caterpillar was reported from areas like Tezpur and Borsola in North Bank, Dooars and Upper Assam. Red slug incidence increased in some areas of the North Bank and Eastern Dooars. Helopeltis was quite severe in April and again in September in the plains areas of West Bengal. Jassids and thrips were serious in Darjeeling and some plains estates in all districts.

Cockchafer appeared for the first time on the North Bank and was serious in some areas in particular in the Tezpur circle. This pest was again serious in some estates in the Dooars and Terai and appears to be on the increase.

(d) Diseases

There was a severe incidence of blister blight in most estates in Upper Assam during the 1972 spring period. This took many managers by surprise and control was hampered by the fact that there was a temporary shortage of copper fungicides.

As usual red rust was severe in young tea areas. The damage caused by this disease is not often appreciated with the result that control measures are neglected.

Routine advices on steps to take to control black rot were given whenever the occasion arose.

8. Agricultural Machinery

Complaints still continued to pour in on the inefficiency of the indigenously manufactured power sprayers. Aspee Bolo, Autoblo, Jawan, Turblo and Micronette are the common ones being used and most of them are fitted with the Villiers engine. During discussions Member estates have been advised to follow the recommendations on the maintenance of these sprayers and those who could strictly adhere to these, obtained better results. However, the fact remains that there is still room for improvement.

Aspee Back Pak is the most popular sprayer for herbicide application. Estates appeared to be satisfied with its performance—maintenance is also easy for spare parts are readily obtainable but our experience at Borbhetta is that the plastic piston and cylinder barrel get corroded quickly particularly if wettable powders are used along with Gramoxone.

ADVISORY PLOTS AND EXPERIMENTS

Out-Stations Plots

1. General : Plots are maintained at all outstation : North Bank at Thakurbari, Cachar at Silcoorie, West Bengal at Nagrakata and the Clonal Proving Station in Darjeeling. Except for the Proving Station in Darjeeling, most of the work is aimed at growing multiplication plots of Tocklai release clones for distribution to Member estates. This work is reported in a little more detail below. In addition, *ad hoc* trials and observations of different management practices are undertaken as and when possible. The extent of these is already largely determined by the resources available. A brief report on this work is given below.

2. Release of Tocklai Clones

The responsibility for release in all areas has been taken over by the Advisory Department with effect from 1st January 1973. In the 1972 season advisory released clonal material from three centres viz. North Bank, Cachar and Dooars.

(a) **North Bank :** Just over 1,35,000 cuttings and 45 scions of Tocklai vegetative clones were released to Member estates on the North Bank from the North Bank Advisory headquarters at Thakurbari.

(b) **Cachar :** Nearly 2,62,000 cuttings and 15 scions of Tocklai vegetative clones were released to Member estates in Cachar from the Ca har Advisory branch at Silcoorie.

(c) **Dooars & Terai :** Nearly 4,21,000 cuttings and 1,700 scions of Tocklai vegetative clones were released to Member estates in West Bengal from the Nagrakata headquarters. This registers a big increase in the number of cuttings over the previous year but there is a decline in the number of scions distribution. In addition 7,800 cuttings and just over 1,600 scions of the two generative clones that make up the biclonal stocks 449 and 450, were released.

3. Experiments

(a) North Bank (Thakurbari)

Just over 2000 kg of green leaf was harvested in the year under review and single plot yield trials were laid out with 7 Tocklai release clones.

(b) Cachar (Silcoorie)

Nearly 2600 kg of green leaf was harvested in the year under review as against 1700 the year before.

A number of look-see plucking and skiffing trials were laid out in the plots, the results of which will be known at the end of 1973.

In addition, 4 clones that may be released in future have been established.

(c) Dooars (Nagrakata)

(i) **General :** The rainfall in early 1972 was well distributed and above average. However, there has again been a severe drought during the 1972/73 cold weather which has caused a lot of die back and some deaths in the plots. This has given us yet another opportunity of assessing and cenfirming the drought resistant properties of a wide range of clones planted in our plots. Unpruned teas, as expected, have suffered more severely than deep skiffed and pruned teas. The clonal multiplication plots which were pruned in the middle of November have withstood the drought fairly well, but wilting and shedding of leaves were noticed on some clones, including TV 19. It was interesting to note that the heavily mulched young tea which was centered in October withstood drought satisfactorily although it had plenty of foliage during the height of drought.

The severe damage done to tea by drought and hailstrom in 1970-71 was reported last year. The tea in the plots being young and healthy made a remarkable recovery in 1972 and it was found that on the majority of bushes the lesions caused by hail had callused over well.

Green leaf harvested in the year under review was just over 19,000 kg as compared to nearly 20,000 kg the previous year. The decrease was due to the fact that a number of plots were rested and some plots of the discarded clones were uprooted.

(ii) **Agricultural Trial 1967/63 :** This was planted in 1967/68 with the object of comparing the growth, yield and reaction to Dooars conditions of 15 Tocklai release clones, 2 clones from Mal against a seed standard of Stock 203. Five clones have been discarded in view of their poor drought resistance. These are : TV 2, TV 6, TV 13, TV 15 and one Mal clone A/19/X.

Observations on method of treatment of young tea in the establishment period are also being made in these plots.

(iii) **Observation Plots :** Not one clone is an obvious success but as far as cup characters of the clones are concerned, there is still an element of doubt and, therefore, it has been decided that those showing some promise in yield will be manufactured in 1973 to evaluate their cup characters finally.

(iv) **Nitrogen Response on different clones :** Planting of this trial has now been completed with six Tocklai release clones viz. TV 1, TV 9, TV 11, TV 12, TV 16 and TV 18. Application of treatments will start in 1974.

(v) **Quality Testing Scheme**

(a) **1969 and 1970 trials :** Quality testing on ten clones planted in 1969 and 1970 will start in 1973.

(b) **1971 trial :** Routine work continued on this trial which included one clone from an estate.

(c) **1972 trial :** Another trial with two estate clones was planted.

(vi) **Nanda Devi Seed Bari (Stock 378) :** The seed bari has improved considerably but has unfortunately been adversely affected by drought again in 1972-73 cold weather. However, intensive management continues in order to produce seeds for release to Darjeeling estates in 1973.

(vii) **Establishment of Future Release Clones:** Nine clones received from Tocklai were planted in the year under review.

(viii) **Extension area :** This area has been made ready for a new agricultural trial which will test new Tocklai clones against known standards and will be planted in 1973.

(d) **Clonal Proving Station Darjeeling (Ging T.E.)**

(i) **Trials A, B & C :** Plot yields were recorded and samples manufactured throughout the season. One block in Trial A was uprooted and rehabilitated during the year under review to prepare the soil for future trials.

(ii) **Trials D & E :** Yield records were maintained and observation on growth made. Samples from Trial D were manufactured throughout the season.

The details of these trials were given in our 1971/72 Annual Report.

No planting was done during the year under report since no clones were offered for trial from estates.

There are now 45 clones under trial at the Proving Station and their yields and cup characters are being compared against the Nanda Devi standard. In addition, hybrid leaf from a nearby area on Ging T. E. is also used as an additional standard at the time of manufacture.

It is again appropriate to record our appreciation of the excellent co-operation received from Ging T. E. over the running of the Proving Station.

4. **Meteorological Station :** Regular readings were recorded in the three fully equipped meteorological stations at Silcoorie, Nagrakata and Nagri Farm (Darjeeling).

In addition a new station was set up at Thakurbari by the Soils Department and records were kept by Advisory Department from the beginning of 1973.

5. Factory : Some modifications were made in the miniature factory at Ging T. E. to improve the drying. Towards the end of 1972 the miniature factory at Nagrakata was completed and some manufacture was done with the aim to standardise manufacture. It is expected that the factory will be fully operational from the start of the 1973 season.

Experiments on Tea Estates

A review of all estate experiments during the preparation of the programme of work for 1973-77 showed that a large number of these were either improperly conducted or did not meet the objectives for which they were planned. All such experiments were discarded in favour of new coordinated trials.

A complete list of Advisory Department experiments is given in Appendix A, the table below gives the number of experiments being conducted in the districts.

Tea District	No. of Experiments after 1972-1973	up to 1972-73
South Bank	6	24
North Bank	2	13
Cachar	1	11
Dooars	15	20
Terai	3	4
Darjeeling	5	12

This is a big reduction over the number conducted in previous years. The plan is to lay out new coordinated experiments in 1973 to fit in with the new programme of work. The system of collecting data on estate trials in Assam has also been re-vamped and brought in line with that existing in West Bengal.

MEETINGS AND LECTURE COURSES

A number of Annual General Meetings of Producer Associations were attended by Advisory Officers :

Area Scientific Committees

There are 9 Area Scientific Committees in the tea districts of N. E. India. Details of the number of meetings held are given below :

South Bank East	3	meetings
,, ,, Central	2	,,
,, ,, West	2	,,
North ,, East	4	,,
,, ,, West	4	,,
Dooars	4	,,
Terai	2	,,
Darjeeling	2	,,

Nearly always the formal meetings were followed by group discussions and these proved a useful platform for a free exchange of ideas and improved the liaison between the planter and scientific staff.

The Dooars Area Scientific Committee was the host to all other committees at a joint meeting held early in March. Nearly all committees were represented at the meeting and also a large number of Tocklai specialist officers attended. In addition, the Deputy Director, UPASI, was also present. Field demonstrations, discussions and social arrangements were very well organised by the Dooars Committee and all attending agreed that the meeting was a great success and congratulated the Committee and Secretary for the excellent arrangements.

The Area Scientific Committees also arranged seminars on different subjects and these were found to be very useful. The details of the seminars held in the year under review are as follows :

South Bank East— One seminar on raising and planting of clones, pruning and skiffing.

South Bank West— One seminar on nursery and young tea management and manufacture.

North Bank East & West— One seminar each on pruning cycle.

Cachar — One seminar on herbicides.

Lecture Courses

Two three-day courses on Agricultural chemicals were held during the year. One course for surveyors on drainage and three courses on surveying and drainage for planters were also held during the year. The courses were well attended.

Visitors

As usual, a large number of persons visited Tocklai and the outstations. Dr. G. S. Venkata Ram, Deputy Director, UPASI, visited all advisory stations in March 1973.

Summary of Results

ADVISORY DEPARTMENT FIELD EXPERIMENTS

Brief summaries of some of the experiments conducted by the Department are given below.

Nutrition

Potash

Dooars & Terai

High level potash trials were laid out in 1967 to test the level at which application of potash induced magnesium deficiency. At no time has there been any indication that application of potash upto 360 kg K_2O/ha can cause magnesium deficiency. In addition combined analysis of yield data from all the four sites for 1971 and 1972 shows that there has been no significant response to potash application.

Nitrogen

All tea districts

A large number of trials on tea estates have been conducted for a number of years now on split applications of nitrogen. In all but one of the Assam trials, there is no indication that splitting the nitrogen dose at low or high levels results in any increase in crop. There is also no indication that potash will increase the response to levels of nitrogen higher than those normally applied i.e. 120-135 kg N/ha, whether application is split or not.

In one experiment in the Dooars (D. 33) on a sandy soil the 1972 results show that nitrogen at 110 and 220 kg/ha, whether applied in single or split doses is significantly better than no nitrogen, but there is no significant difference between 110 and 220 kg N/ha applied in one, two or four divided doses. There is also no difference whether 220 kg N/ha is applied once, or divided into 2, 4 or 8 equal doses.

In one experiment in Assam (AS. 56) where nitrogen in one plot is applied as ammophos and in the other as sulphate of ammonia with potash, splitting the dose of nitrogen has given a significant increase in crop over single application in most of the four levels of nitrogen tried.

This is the only case in Assam where split application of nitrogen has resulted in an increase in yield over nitrogen applied in one dose. All the experiments have their limitations and have therefore been stopped. Further experiments on plant nutrition will be planned as and when resources become available.

Infilling

Dooars & Terai

An experiment designed to determine the yield increase due to infilling in tea having 10-25% vacancy was laid out on 6 estates in the Dooars and Terai in 1969. Infilling was done in October 1969 and the infills were brought up by the standard method. Pruning of the majority of infills was completed in October 1970 and thereafter the infills were pruned and plucked in the same manner as the mature tea.

A combined analysis of five of the six sites shows that in 1971 the effect of infilling (done in 1969) was highly significant and resulted in an all round crop increase of 13-16%. Infilling following medium pruning increased the yield by over 30% in those plots where hedge infilling was done; and over 20% where single infilling was carried out.

Soil Rehabilitation

Dooars

The 1972 results of experiment D.28 again has shown that even 6 years after planting the differences remain significant between 2 years rehabilitation with *Mimosa invisa* as the green crop, one year rehabilitation under *M. invisa* and no-rehabilitation. There is also a significant difference between subsoiling and ploughing and no sub-soiling and ploughing, in favour of the former. The highest yield was obtained from plots that where rehabilitated for two years after subsoiling and ploughing and the lowest yield from plots where there was no rehabilitation and no subsoiling and ploughing. The difference in favour of the former is over 600 kg/ha, which is a 65% increase.

Plucking

Darjeeling

A plucking experiment (Dj. 18) was started in Darjeeling in 1961 and the eleven years results show that plucking to the janam in the year after the prune gives the best results whereas leaving a leaf at the start of the first flush and then plucking to the janam is the best system in the second year when the bushes were light skiffed or skiffed to level off. However, it is worth noting that the system that demands leaving of leaf early in the season results in a loss of first and second flush crop when compared to plucking to the janam.

General

Mr. B. C. Phukan was appointed to the post of Second Agronomist and he joined his duties on 1. 8. 72. Mr. S. N. Sarmah joined as Junior Scientific Assistant on 20.12.72.

RESEARCH AND EXPERIMENT

Planting and Spacing

Three spacing experiments are in progress at Borbhetta. The oldest (B 104) was started in 1957 and the treatments consisted of two *jats* (Betjan and Stock 203), five spacings (120 cm × 120 cm, 100 × 98 cm, 150 × 75 cm, 150 × 60 cm and 120 × 60 cm) and three levels of nitrogen (90, 135 and 180 kg/ha). Spacing within the above range did not have any effect on yield after the tea had reached the age of four years. Closer spacings gave higher yields in the first four years. There was no difference between levels of nitrogen (90, 135, 180 kg/ha N) from 1962 to 1968. Higher levels of nitrogen have markedly depressed yield thereafter. Betjan outyielded Stock 203 upto 1963. The two were not differentiable during 1964-66 although in all these years Stock 203 was improving over Betjan. Thereafter Stock 203 outyielded Betjan.

The results of another factorial experiment (B 8/1) on clonal tea were presented in last years Annual Report. The results are graphically represented in Figure 1.

From the above it can be seen that except for 120 cm×45 cm there is a progressive increase in yield with closer spacings. It is also interesting to note that Clone 106/1 (T.V. 9) outyielded Clone 19/29/13 (T.V. 1) in 1970 and there was no difference between them in 1971. In 1972 Clone 19/29/13 (T.V. 1) outyielded Clone 106/1 (T.V. 9). These observations indicate that Clone 106/1 is an early starter but its yield potential is not as high as the other clone. Another interesting observation

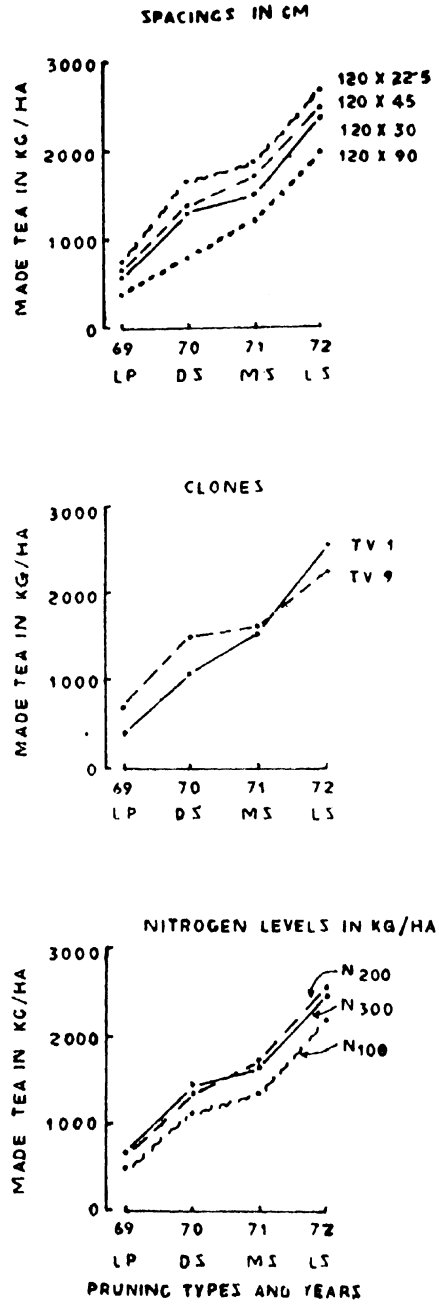


Fig. 1. Effect of different spacings, clones and nitrogen levels on yield of made tea.

is that 200 kg N/ha has continued to give higher yield than 100 kg N/ha, but no difference has been observed between 200 kg and 300 kg per hectare nitrogen doses.

Another experiment on *jat* tea (B 8/2) started in 1966 gave interesting results. The results are recorded in Table 1.

Table 1. Effect of spacing on yield of made tea (kg/ha).

Treatment	Plant population per ha	1968	1969 LP	1970 DS	* 1971 MS	* 1972 LS	Average No. of Pruning Sticks, 1973	
							Per bush	Per plot
120 cm × 120 cm	6944	62	234	646	964	1547	25.0	1881
120 cm × 90 cm	9259	82	292	714	1146	1724	18.5	1855
120 cm × 90 cm** (doubleton)	18518	86	329	859	1255	1687	23.0	2305
120 cm × 75 cm	11111	76	276	755	—	—	20.1	2418
120 cm × 60 cm	13888	108	340	885	1260	1859	16.7	2505
120 cm × 75 cm × 75 cm	13675	98	368	1047	1359	1823	18.0	2606
C. D. at P. 05		26	79	162	242	NS		
C. V. %		20.1	17.0	13.2	13.1	9.3		

*1971 & 1972 analysis were done eliminating the 120 cm × 75 cm treatment where yields were very poor due to plot heterogeneity.
**Two plants planted in one hole.

There was progressive increase in yield with closer spacing upto 1971. The effect of spacing was not significant in 1972 and these results are in conformity with the result of an earlier experiment (B 104) where the difference between spacings became non-significant after four years.

Bringing Young Tea into Bearing

An area was planted with Clone T.V.9 in August 1968 in single hedge of 120 cm × 60 cm and staggered double hedge of 120 × 90 × 60 cm with the object of assessing the nature of yield progression with the low tipping method of bringing up young tea. The area is shaded with *Indigofera teysmanii*. The yields obtained from 1969 onwards are recorded in Table 2.

Table 2. Effect of spacing-cum-method of planting* on yield of made tea (kg/ha).

Spacing	Made tea in kg/ha			
	1969*	1970	1971	1972
Staggered double hedge 120 cm × 60 cm × 90 cm (12345 plants/ha)	196	1303	1723	2162
Single hedge 120 cm × 60 cm (13888 plants/ha)	571	1605	1826	2322

* 1969 yields recorded from July to November only.

These yields are much higher than what are obtained by the conventional method of bringing up young tea under similar conditions.

This tea was pruned at different heights ranging from 40 cm to 60 cm in January, 1973 to find out at what height a good frame was formed. It was found that frame development was not satisfactory at any height in the above range. Pruning sticks were counted and the diameter of the pruning sticks at the height of cut was measured. The results are given in Table 3.

Table 3. Number and diameter of sticks at different pruning heights in low tipped tea.

Height of Prune	No. of Sticks per bush	Mean thickness of branches in cm
40 cm	8	2.70
45 cm	9	2.45
50 cm	12	2.40
55 cm	24	1.90
60 cm	24	1.70

Cuts at a low level did not leave many sticks and the few sticks did not form a good permanent frame. It was, therefore, felt that keeping the tea

bushes unpruned for three or four years, as prescribed under low tipping method of bringing up young tea, would be detrimental to the development of a good permanent frame and as such introduction of a frame forming prune 12 to 24 months after the first prune and decentre was considered essential for the development of a good frame.

Plucking

The results of an experiment on plucking started in 1971 are recorded in Table 4.

Table 4. Effect of plucking methods on yield of made tea (kg/ha).

Treatments	1971 (M. S.)		1972 (L. P.)	
	Without broken back leaf	With* broken back leaf	Without broken back leaf	With broken back leaf
T_1 — Pluck black to janam	2149	2149	1851	1851
T_2 — Pluck standard leaf only, no breaking back	1454	1454	1325	1325
T_3 — Pluck standar l leaf and break back to janam	1558	2000*	1312	1838*
T_4 — Pluck standard leaf over fish leaf, no breaking back	1273	1273	1169	1169
T_5 — Pluck standard leaf over fish leaf, break back to level off	1487	1896*	1240	1617*
C. D. at P.05	115	134	131	134
C. V. %	5.3	5.6	6.9	6.2

* In T_3 and T_5, first standard leaf comprising of two and a bud, large one and a bud and single banjhi was plucked and weighed. Then the remaining growth comprising mainly of 3rd leaf was plucked to janam and weighed. The figures marked with asterisk are the total of these two weighments.

When broken back parts are included plucking black to *janam* has given the highest yield in the medium skiffed year but in the pruned year there is no difference between T_1 and T_3. Standard leaf accounts for roughly 75 per cent of the total if all the growth above *janam* is taken into the basket on a seven day round. Fish leaf plucking has given significantly lower yield compared to *janam* plucking.

The monthly variation in the percentage of broken back leaf in the two different treatments is shown in Table 5.

Table 5. Per cent broken back leaf in different months.

Treatments	May	June	July	Aug.	Sept.	Oct.	Nov.
T_3 —Pluck standard leaf and break back to *janam*	37.3	38.1	37.8	34.5	20.8	18.1	10.1
T_5 —Pluck standard leaf over fish-leaf and break back to level off	33.2	30.1	28.6	26.8	22.8	18.2	1.5

It is interesting to see that of the two, T_5 produced less coarse leaf (represented by broken back leaf in Table 5) during May - August and again in November. The per cent coarse leaf during September and October was practically the same in both treatments.

Manuring

A number of experiments on different aspects of manuring are being conducted at Borbhetta. The results of some of the experiments are briefly discussed below.

Nitrogen Manuring

Experiments on doses and split application of nitrogen (B 8/1, B 111/2, B 113/1) are continuing and the results confirm the earlier finding that single dose application gives the same result as split application. In one experiment there was no difference between 90 kg and 135 kg N/ha. In another experiment there was no difference between 112, 157 and 224 kg N/ha when applied either singly or in split doses. In the third experiment (B 8/1) at Borbhetta where 100, 200 and 300 kg per hectare nitrogen doses were tried on clonal tea planted in

1966 significant increase in yield due to application of 200 kg N/ha was recorded in 1971 and 1972. The optimum nitrogen dose was statistically computed to be 235.09±24.14 kg/ha in 1971 and 232.51± 21.18 kg/ha in 1972. This is for the first time that response to such high dose of nitrogen has been recorded in a field experiment in N. E. India (see Fig. 2).

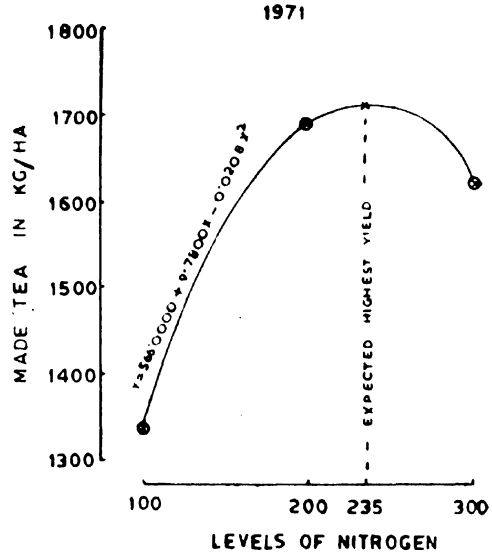
Phosphate Manuring

The experiment (B 43 C.2) was started in 1970 to compare the efficiency of different sources of phosphate applied at 40 kg P_2O_5 per hectare in the presence of 100 kg N and 40 kg K_2O/ha. The treatments were: control, phosphate as superphosphate, rock phosphate, ammophos and nitrophosphate. There was no difference between treatments in any of the three years and it can be concluded that phosphate application in any of the above forms has not given higher yield than control under the conditions of this experiment. This experiment has since been discontinued.

Another experiment where phosphate has been applied as superphosphate from 1960 at 0, 45, 90 and 180 kg P_2O_5 per hectare on Clone T. V. 2 has given interesting results. In this experiment upto 1970 phosphate application had a tendency to depress crop and in 1970 phosphate at 180 kg/ha showed a large reduction in crop as compared to control. In 1971 the trend of response to phosphate fertilisation reversed as is clear from yield data in Table 6.

Table 6. Effect of differential phosphate fertilisation on yield of made tea (kg/ha).

Treatments	1970 LP	1971 DS	1972 MS	Total
No Phosphate	1588	1708	2467	5763
45 kg P_2O_5 /ha	1576	1744	2562	5882
90 kg P_2O_5 /ha	1493	1790	2675	5958
180 kg P_2O_5 /ha	1371	1680	2594	5648
C. D. P. 05	109	NS	NS	
C. V. %	10.2	10.2	9.1	



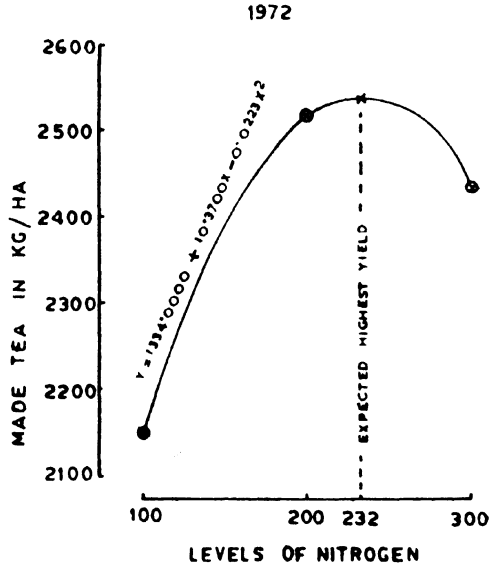


Fig. 2. Response of clonal tea to different levels of nitrogen

Application of phosphate at 45 and 90 kg rates resulted in a positive response in 1971 which however could not be manifested at a statistically signifi-

cant level. This trend became more pronounced in 1972. The reversal in the trend of response may be attributed to chemical weed control in this area from 1970 season : a mass of feeder roots has developed in the top layer of the soil which could have ensured a better utilisation of the applied phosphate. However, the highest level of phosphate has depressed yield, though nonsignificantly, compared to lower doses.

Potash Manuring

The yield data from experiments B 5.1 and B 105 continued to give results similar to the ones reported in Annual Report, 1970-71. Response to potash was obtained at all levels. The results from B 105 are presented in Table 7.

Table 7. Effect of differential potash fertilisation on yield of made tea (kg/ha).

Treatments	1970 LP	1971 DS	1972 MS
No. K_2O	1279	1490	2289
45 kg K_2O/ha	1530	1708	2555
90 kg K_2O/ha	1596	1810	2652
180 kg K_2O_5/ha	1625	1913	2803
C. D. P. 05	109	126	167
C. V. %	10.2	10.2	9.1

Prior to 1969, 180 kg K_2O per hectare outyielded the lower doses by large margins. But in 1970-72, 90 kg and 180 kg per hectare doses were at par. In 1970 even 45 kg/ha was at par with 180 kg/ha. It, therefore, appears that application of high doses of potash over the years has resulted in a build up of potash in the soil. Therefore, there is little or no response to application of higher levels of potash now.

Micronutrients

Zinc : One experiment (B 108.1/2) with foliar application of zinc sulphate at the rate of 24 kg/ha in 4 splits of 6 kg/ha at bimonthly intervals was started in the middle of 1970 season. The results obtained in 1971 and 1972 are presented in Table 8.

Table 8. Effect of zinc spray on the yield of made tea (kg/ha).

Treatments	1971 (U. P.)		1972 (L. P.)	
	Made tea in kg/ha	No. of Shoots/kg	Made tea in kg/ha	No. of Shoots/k
Zinc Sulphate	2383	1968	1932	1430
Water Spray	2204	1983	1756	1402
't' test	Significant		N. S.	
C. V. %	9.2		15.0	

Unlike the previous year (1971) the treatment effect failed to be manifested at a significant level in 1972. This could possibly be either due to near sufficiency of zinc after the 1971 treatment or due to lesser response in the pruned year. Experiments in Ceylon and South India suggest that response to zinc is more pronounced in the later years of the pruning cycle.

Scorching with Zinc Sulphate Spray : Trials were also conducted on bright days in August, 1972 to find out the maximum safe concentration of zinc sulphate for foliar application with hand and power sprayers. No scorching was observed upto 3 per cent concentrations of $ZnSO_4$ in the case of hand sprayers and upto 5 per cent concentration in the case of power sprayers.

Boron : Another trial with foliar application of Borax was started in August 1971. Borax at 24 kg/ha in four splits of 6 kg was applied four times at monthly interval in August, September, October and November, 1971 and in May, June, July and August 1972. There were two plots with Borax and two plots without Borax. The mean yields of the two treatments from August to November in 1971 and for the whole of 1972 are tabulated below :

	1971 (U.P.)	1972 (L. P.)
Water spray—	893	1623
Borax	1055	1867

Long Term Agricultural Trial of Tocklai Clones

To study their yield performance, a long term agricultural trial was started with Tocklai release clones which were planted in 1966-67. The yield data of these clones for the year 1972 when the bushes were medium skiffed are recorded in Table 9. The crop distribution is also shown in the same table.

It is too early to draw conclusions on the yield performance of different clones. The experiment is in progress and proper comparison will be possible after the completion of one pruning cycle. It is, however, evident that the per cent crop distribution has not varied to any appreciable extent. Only T.V. 7 has given very low per cent early crop and very high per cent main season crop.

Table 9. Yield of made tea in kg per hectare for 1972 (Medium skiffed) from different Tocklai clones. (*Figures in bracket show the crop distribution in per cent*)

Clone	Early	Main	Backend	Total
TV 14	563 (30%)	1034 (54%)	310 (16%)	1907
TV 10	545 (31%)	933 (52%)	305 (17%)	1783
TV 4	559 (32%)	966 (55%)	219 (13%)	1744
TV 11	552 (32%)	906 (52%)	277 (16%)	1735
TV 7	392 (23%)	1078 (64%)	221 (13%)	1691
TV 9	434 (27%)	902 (56%)	267 (17%)	1603
TV 8	512 (32%)	845 (53%)	232 (15%)	1589
TV 1	452 (29%)	855 (55%)	242 (16%)	1549
TV 12	457 (31%)	782 (52%)	257 (17%)	1496
TV 2	351 (27%)	699 (55%)	226 (18%)	1276
TV 13	322 (26%)	684 (56%)	221 (18%)	1227
TV 6	289 (27%)	576 (55%)	194 (18%)	1059
Betjan	505 (32%)	862 (54%)	233 (14%)	1600
			C.D. at P. 05	236
			C. V.%	10.6

Early crop — upto end June
Main crop — upto mid October
Backend crop — upto mid December

Chemical Weed Control

Three new herbicides, namely, Ansar, Probe and Roundup were tried at Borbhetta. A brief report on each of the three herbicides is given below.

Roundup : This is a product of Monsanto Chemicals. The formulation contains 36 per cent active ingredient. It was sprayed in a predominantly thatchy area at 3 litres, 6 litres, 9 litres and 12 litres of the formulation per hectare on 6th April, 1972. All weeds including thatch were completely killed at even the lowest dose but reinfestation with broad leaved weeds, mainly *Borreria hispida* (*bagracote*) started one month later. It was interesting to note that there was no regrowth of thatch. Repeat sprays were given on 6th June and 23rd August but they were against weeds germinating from seeds. This herbicide is translocated and does not have any preemergence activity.

The toxicity of this herbicide to tea was studied by spraying it at different concentrations on the leaves as well as on the soil around one year old sleeve-grown plants. Soil application even upto 8 litres per hectare did not have any adverse effect on growing plants. Direct spraying of the herbicide on the plant upto 4 litres per hectare did not show any adverse effect, although some adverse effect was noticed at higher doses. This herbicide killed all the common weeds except *Paspalum scrobiculatum*, which was partially resistant. Further trials with this herbicide are continuing. The herbicide is not yet commercially available.

Probe : A detailed report on Probe has been published in the December, 1972 issue of Two & A Bud. Trials conducted so far suggest it to be useful in cocktails with Gramoxone, 2,4-D and Dalapon. It is a good preemergence herbicide, but is not yet available.

Ansar : Trials with Daconate (MSMA from Diamond Alkali Corporation) were first conducted in 1970. In these trials it was found effective for the control of broad leaved weeds and shallow rooted grasses. It was not effective against *Saccharum spontaneum* and *Imperata cylindrica*. Subsequently, Ansar was tried in combination with 2,4-D, and Gramoxone and was found to give satisfactory control of all weeds except the thatch group. It is however interesting to record that on the basis of equal dose of formulation Daconate was more effective than Ansar. Further trials are in progress.

The toxicity of this herbicide to tea was studied by spraying it at different concentrations on the leaves as well as on the soil around one year old sleeve-grown plants. Soil application even at two litres/hectare was toxic and two of the five test plants died. Direct spraying of the herbicide on the plants even at one litre/ha killed three out of the five test plants. Tea from Ansar treated plots is being analysed by the Soils Department for arsenic residue/uptake.

Control of Oxalis

Oxalis acetosella is becoming the dominant weed in many areas where gramoxone has been used for a number of years. This is a low growing species and covers the ground completely during January-May. It dies out with the onset of the heavy rains. It is propagated from bulbils (small bulbs) which are very persistent. Destruction of the foliage either manually or chemically only stimulates the ripening and multiplication of the bulbils

and consequently the plants. Most herbicides appear to be almost without effect for Oxalis control. To what extent Oxalis is harming the tea is not known. One thing is fairly certain and that is that the Oxalis plants will use quite a lot of the moisture from the top three to four inches of the soil. A number of herbicides-Lasso, Dalapon, Probe, Ansar, DSMA, Gramoxone, Fernoxone and Karmex were tried against Oxalis. Probe at 4 kg/ha gave the best control followed by Gramoxone 2 litres + Fernoxone 1 kg per hectare, Gramoxone 2 litres + Karmex 4 kg per hectare and Gramoxone 2 litres per hectare respectively.

Effect of Different Herbicide Cocktails in a Thatchy Area

The various cocktails tried included varying doses of Karmex + Gramoxone, Karmex + Dalapon + Gramoxone, Ansar + Gramoxone, Ansar + Dalapon + Gramoxone, Amitrole + Dalapon, Probe + Dalapon + Gramoxone, Probe + Gramoxone. It was found that Probe 4 kg/ha + Dalapon 4 kg/ha + Gramoxone 750 ml/ha gave the best control and was closely followed by Probe 4 kg/ha + Gramoxone 750 ml/ha.

Effect of Gramoxone on Metal Containers

There was some complaint from estates that gramoxone solution kept overnight corroded metal containers. To check this 1:200 gramoxone solution was stored in containers of galvanised iron, iron, aluminium and brass. Corrosion was observed almost immediately in the galvanised iron container. Corrosion was observed in iron and aluminium containers also but to a lesser extent. Hence containers of the above metals are not considered suitable for storing gramoxone solution. There was no detectable corrosion on brass : only a few black dot like patches were observed on the body of the container.

Some Factors Affecting Dry Matter Content in Plucked Tea Shoots

Dry matter content of tea shoots determines the recovery of made tea from green leaf. This, in turn, is dependent on a number of environmental and management factors like manuring, pruning, shade, *jat* etc. Two long-term manuring experiments, details of which are given below, were selected for the purpose of this study. In experiment No. 1 tea of Tingamira *jat* was planted in 1962 in plots which were receiving different combinations of N, P and K.

In experiment No. 2, all combinations at four levels of P and K at a constant level of nitrogen were being applied on 1958 planted clonal tea since 1960. The observations on shoot weight were started in end June, 1972 and were repeated at fortnightly intervals on 11 occasions. Composite samples of 100 gm freshly plucked leaf of every treatment were taken and dried in an air oven at 75° C till the weight was constant.

Effect of Nitrogen with and without Shade on Dry Matter Content : The mean effects of nitrogen in the presence and absence of shade are given in Table 10.

Table 10. Effect of levels of N with and without shade on dry matter content (gm/100 gm) of plucked tea shoots.

Levels of Nitrogen	Shade	No. Shade
No. Nitrogen	20.31	23.29
45 kg N/ha	20.76	23.65
90 kg N/ha	21.04	23.85
135 kg N/ha	21.48	24.07
C. D. at P.05	0.43	0.40
C. V. %	2.44	2.02

From the above table it can be seen that the dry matter content in young tea shoots is nearly three per cent more under unshaded tea. Application of nitrogen also increased the dry matter accumulation in plucked tea shoots. Single degree of freedom analysis of the nitrogen effect both with and without shade indicated that only the linear effect was significant. This suggests that the rate of increase is proportional to the dose of nitrogen.

Effect of Phosphate with and without Shade on Dry Matter Content : Information on the effect of levels of phosphorus on dry matter per cent is available from two experiments and is given in Table 11.

Table 11. Effect of levels of phosphate with and without shade on dry matter content (gm/100 gm) of plucked tea shoots.

Area B 5.1			Area B 105	
Levels of P_2O_5	Shade	No. Shade	Levels of P_2O_5	Shade
No. P_2O_5	20.88	23.78	No. P_2O_5	22.30
25 kg P_2O_5/ha	20.92	23.65	45 kg P_2O_5/ha	22.38
C. D. at P. O5	N. S.	N. S.	90 kg P_2O_5/ha	22.19
C. V. %	2.41	2.02	180 kg P_2O_5/ha	22.09
			C. D. at P.O5	0.18
			C. V. %	1.74

Low dose of phosphorus did not affect the dry matter in plucked tea shoots, but higher doses reduced the dry matter content. The reduction in dry weight was proportional to the increase in phosphate level upto the highest level used viz ; 180 kg/ha.

Effect of Potash with and without Shade on Dry Matter Content : The mean effects of potash in the presence and absence of shade are given in Table 12.

Table 12. Effect of levels of potash with and without shade on dry matter content (gm/100 gm) of plucked tea shoots.

Area B 5.1			Area B 105	
Levels of K_2O	Shade	No Shade	Levels of K_2O	Shade
No. K_2O	21.32	24.14	No. K_2O	22.97
90 kg K_2O/ha	20.49	23.29	45 kg K_2O/ha	22.24
C. D. at P. O5	0.16	0.14	90 kg K_2O/ha	21.98
C. V. %	2.41	2.02	180 kg K_2O/ha	21.77
			C. D. at P. O5	0.18
			C. V. %	1.74

Application of potash both under shade and without shade has decreased the dry matter content in both the experiments. The effect of graded doses of potash on dry matter under shade can be seen clearly in the results from experiment B 105. The analysis suggested that dry matter per cent was inversely related to increasing levels of K but the rate of decrease was found to decrease with increasing levels of K.

The N × P interaction was significant in the unshaded experiment only. Dry matter per cent went on increasing with increasing doses of N in the presence of phosphate whereas there was no increase in dry matter after 100 kg N dose in the absence of phosphate. (Fig 3).

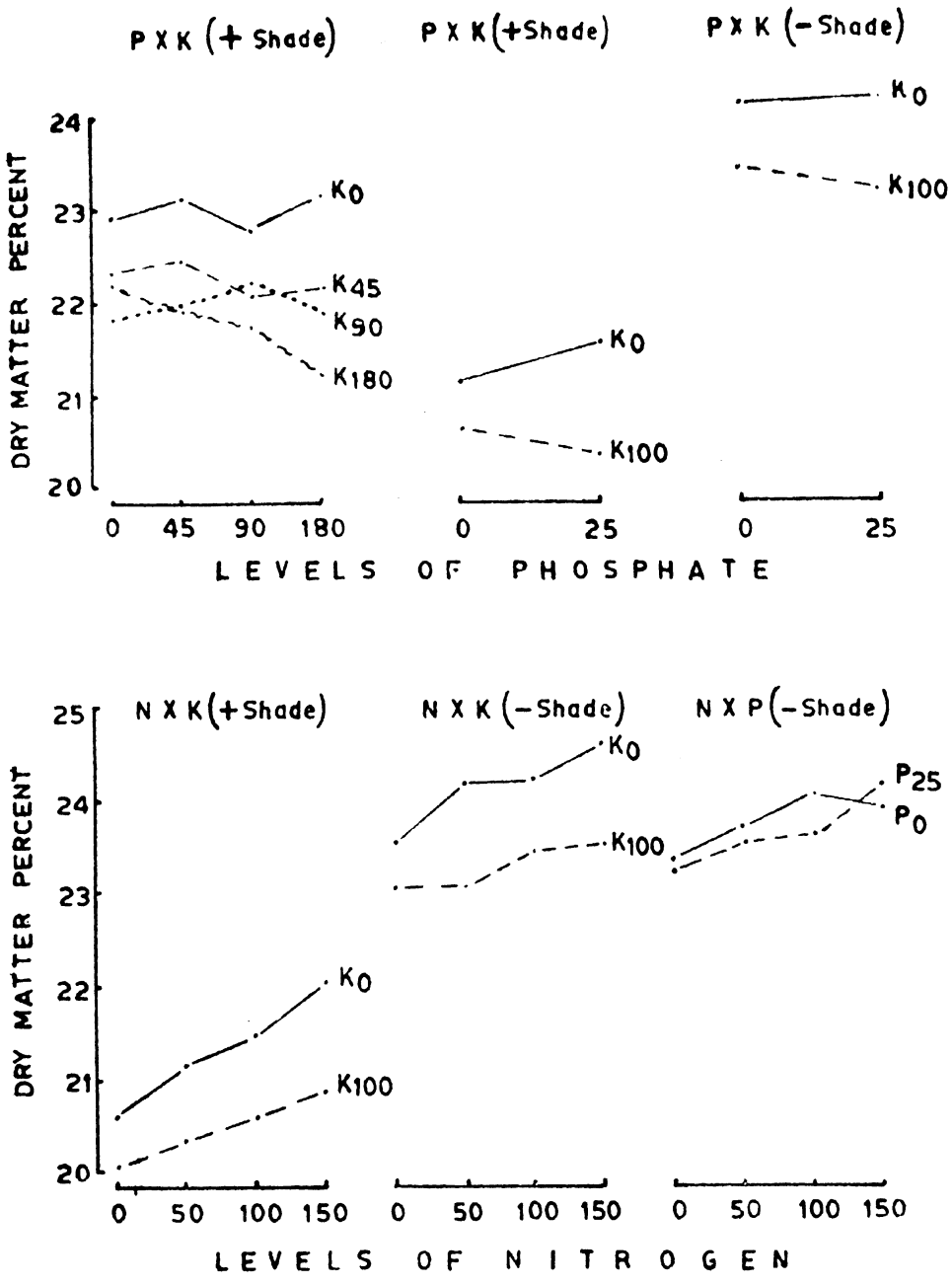


Fig. 3. Effect of different combinations of nitrogen, phosphorus and potassium on dry matter in tea shoots (gm dry weight/100 gm fresh weight).

The N × K interaction was significant both under shade and no shade. The difference in dry matter between potash and no potash treatments was less at lower nitrogen levels and increased at higher levels of nitrogen (Fig 3).

The P × K interaction was significant in both the experiments. Potash in the presence of phosphate appeared to reduce dry matter. Further studies are continuing on this aspect (Fig. 3).

BORBHETTA FIELD EXPERIMENTAL ESTATE REPORT

Labour—The average daily attendance of labourers during the current year, compared with the last four years, is as follows :

Year	No. of labourers engaged.
1968 ..	220.00
1969 ..	208.63
1970 ..	188.30
1971 ..	179.00
1972 ..	183.00

Crop—The total yield of green leaf during the current year, compared with the last four years, is as follows :—

Year	Yield
1968 ..	1,29,021 kg
1969 ..	1,44,985 kg
1970 ..	1,72,868 kg
1971 ..	1,74,555 kg
1972 ..	2,26,455 kg

Of the 1972 crop, 2,18,813 kg green leaf was sold to the Jorehaut Tea Co., Ltd., and the remaining was used for experimental purpose. General plucking was stopped on 1.12.72.

Vegetative Propagation

The following supplies were made to Members/ Outstations from Borbhetta :—

Supplies made	1971-72	1972-73
Pretreated/fresh cuttings of vegetative clones	3,43,515	8,15,300
Scions of vegetative clones	5,540	5,320
Fresh cuttings of generative clones	1,500	9,000
Scions of generative clones	4,820	6,550
Clonal plants	—	785
Grass cuttings	1,300	700

SOIL CHEMISTRY

Cation exchange capacity of clonal tea roots

(i) Investigation was carried out to know whether precision of measurement of root cation exchange capacity remains same when results are expressed on the basis of surface area of roots and dry weight of roots. For this purpose ten different clones were examined. The surface area of roots was determined by the formula :

$$M = \frac{4 \times V}{D}$$, where M = surface area in square meter;

V = volume in c.c.;

and D = diameter of root in mm.

Volume of root was determined by displacement of water, and the diameter of root was determined by ocular micrometer.

Table 1. Data on the cation exchange capacity of clonal tea roots, expressed on the basis of surface area and dry weights.

Clone	Cation Exchange Capacity of white roots (mili equivalent)	S.E.of mean	C.E.C./Sq.m: C.E.C. /100 g.
TV_1	8.27 per Sq. m. 44.07 per 100 g.	± 0.89 ± 1.03	1:5.3
TV_{15}	7.99 per Sq. m. 45.58 per 100 g.	± 0.88 ± 0.87	1:5.7
TV_9	7.65 per Sq. m. 46.05 per 100 g.	± 1.50 ± 1.53	1:6.0
14/6/28	6.80 per Sq. m. 43.98 per 100 g	± 0.97 ± 1.22	1:6.5
TV_6	8.25 per Sq. m. 44.28 per 100 g.	± 0.87 ± 0.74	1:5.4
TV_2	7.45 per Sq. m. 43.02 per 100 g.	± 1.22 ± 1.38	1:5.8
19/16/48	6.32 per Sq. m. 45.12 per 100 g.	± 0.79 ± 1.02	1:7.1
Lushai	7.72 per Sq. m. 40.48 per 100 g.	± 1.23 ± 1.43	1:6.3
TV_{18}	7.74 per Sq. m. 43.15 per 100 g.	± 1.62 ± 1.06	1:5.6
280	8.25 per Sq. m. 43.51 per 100 g.	± 1.35 ± 1.20	1:5.3

The reported standard errors of mean confirm that the precision of C.E.C. measurements by both procedures (surface area and dry weight basis) is about the same. Further, it is interesting to observe that the two procedures maintain almost a constant ratio (on an average C.E.C./Sq. m : C.E.C./100 g :: 1 : 6) irrespective of the clonal differences. This observed constancy is due to the highly significant (r^2 = 0.98) relationship obtained between the volume and weight of clonal roots, the equation being Y = 0.091 + 2.855 X, where Y = the volume of roots, and X = the weight of roots.

It is, therefore, possible to gain accurate information on the cation exchange capacity of clonal tea roots by the conventional method of expressing results on the dry weight basis rather than on the surface area basis which is time consuming.

(ii) Investigations were carried out to find out the proportions in which red and white roots are present in clonal root system, and how far the cation exchange capacity of root systems is affected by the ratios between red and white roots. Results of this study are given in Table 2.

Table 2. Data on the ratio between red and white roots, and the cation exchange capacity of clonal root system.

Clone	Red/White roots (W/W)	C. E. C. of whole root system in m.eq./100 g.
TV_1	1.73	23.39
19/16/48	2.96	19.48
19/22/1	2.12	20.62
TV_{15}	2.92	17.84
TV_2	2.56	18.47
TV_6	2.36	22.10
TV_7	3.39	16.11
Lushai	2.99	18.64
TV_{14}	1.53	24.49
280	0.91	28.35
TV_{18}	3.25	14.68
TV_9	1.58	24.68
TV_3	2.08	20.10
14/6/28	1.25	28.44
Naga	2.05	20.58

Statistical analysis of the above data showed a highly significant positive correlation between root C.E.C. and the ratio of red : white roots (r^2=0.89), equation being Y=5.97 - 0.1741 X, where Y= red/white root ratio, and X= C.E.C. of root system in m. eq./100 g.

Thus it is seen that clones having more quantities of white roots than the red roots have higher cation exchange capacity. It can, therefore, be inferred that the morphological distribution of roots has a dominant role in determining the C.E.C. of clonal tea roots. From practical point of view, it is possible that predominance of white root found in field excavation can be an indicator of higher root C.E.C., i.e., higher capacity to absorb nutrients.

(iii) Investigation was also carried out to ascertain whether the C.E.C. value of whole root system compares favourably with the sum of the C.E.C. of white and red roots estimated separately. The object of this exercise is to confirm or otherwise the accuracy of determining C.E.C. on the whole root system. Results of this investigation are given in Table 3.

Table 3. A comparison of C. E. C. measurements, carried out on whole root system, and fractionated roots.

Clone	Estimated C. E. C. of whole root system (m. eq./100 g.).	C. E. C. of fractionated roots and their total		
		White roots, m. eq./x* g	Red roots, m. eq./y+g	Computed C. E. C. of whole root system, m. eq./100 g.
280	28.36	19.47/41.6 g	7.70/58.4 g	27.17
TV_1	24.78	18.17/40.0 ,,	6.56/60.0 ,,	24.73
14/6/28	24.37	17.76/37.0 ,,	6.93/63.0 ,,	24.69
TV_9	23.30	21.25/45.5 ,,	3.96/54.5 ,,	25.21
TV_{11}	21.73	17.20/40.0 ,,	3.91/60.0 ,,	21.11
TV_6	20.82	13.00/25.0 ,,	7.50/75.0 ,,	20.50
TV_2	17.68	12.30/29.6 ,,	5.85/70.4 ,,	18.15
TV_{15}	17.45	11.34/25.0 ,,	7.50/75.0 ,,	18.34
19/22/4	17.33	9.66/17.2 ,,	7.70/82.8 ,,	17.36
Naga	16.94	12.59/22.2 ,,	4.49/77.8 ,,	17.08
TV_3	15.85	11.56/16.4 ,,	6.52/83.6 ,,	18.08
19/16/48	15.83	8.36/19.2 ,,	8.91/80.8 ,,	17.27
Lushai	15.80	10.32/21.7 ,,	4.86/78.3 ,,	15.18
TV_7	14.36	9.20/20.0 ,,	6.00/80.0 ,,	15.20
TV_{18}	11.33	8.90/16.6 ,,	3.92/83.4 ,,	12.82

Note : * x = Quantity of white roots present in 100 g whole root system
+ y = Quantity of Red roots present in 100 g whole root system

A close agreement between the C.E.C. measurements on the whole root system and the pooled value from fractionated roots has been observed. The statistical analysis shows a 67 per cent predictibility index between the two systems (r = 0.945), i. e., either of the system will give a precise estimate of the root C.E.C.

(iv) Glass house facilities have been organised to enable growing of tea plants under artificial environment. As a next step to this, sand culture technique has been perfected for growing clones fed with nutrient solutions (according to Hewitt). Finally, sand culture experiments in pots have been started to study the following problems :

(a) Relationship between Ca/K supply, root C.E.C., and uptake of Ca and K by different clones (TV_1 and TV_{18}).

(b) Influence of different forms and rates of application of nitrogenous ferti-

lisers on the C.E.C. values of clonal tea roots (TV_1 and TV_{18}).

These pot experiments are progressing well, and will be continued for the current growing season.

Studies on soil potash

(i) **Survey of the native soil potassium fractions**

Preliminary data were reported in Annual Scientific Report, 1971-72, page 34. For purpose of intensive survey ninetythree estates from West Bengal, and ninety estates from Assam have been included covering almost all the sub-districts. These soils were fractionated for three categories of soil potassium, namely, water-soluble, exchangeable and non-exchangeable forms. The survey data are presented in Table 4(a), 4(b), and 4(c).

Table 4(a). Regional distribution of water-soluble potassium.

State	Region	Water soluble potassium					
		Low (0–10 p.p.m.)		Medium (11–20 p.p.m.)		High (> 20 p.p.m.)	
		No. of gardens	p.c. frequency	No. of gardens	p.c. frequency	No. of gardens	p.c. frequency
West Bengal	Darjeeling	5	20	12	48	8	32
,,	Terai & Western Dooars	14	39	13	36	9	25
,,	Eastern Dooars	13	40	13	40	6	20
Assam	North Bank	9	31	15	45	7	24
,,	South Bank	11	28	20	52	8	20
,,	Cachar	8	36	9	41	5	23

It appears that the distribution pattern of low, medium and high water soluble potassium fractions in West Bengal and Assam are practically the same. In both West Bengal and Assam soils, "medium" category of water soluble potassium predominates, followed by "low" and "high" categories respectively.

Table 4(b). Regional distribution of exchangeable potassium.

State	Region	Exchangeable potassium					
		Low (0–40 p.p.m.)		Medium (41-80 p.p.m.)		High (> 80 p.p.m.)	
		No. of gardens	p.c. frequency	No. of gardens	p.c. frequency	No. of gardens	p.c. frequency
West Bengal	Darjeeling	3	12	8	32	14	56
,,	Terai & Western Dooars	5	14	20	56	11	30
,,	Eastern Dooars	13	41	18	56	1	3
Assam	North Bank	9	31	18	62	2	7
,,	South Bank	16	41	16	41	7	18
,,	Cachar	7	32	10	45	5	23

It is seen that "low" exchangeable potassium soils occur much more frequently in Eastern Dooars, North and South Bank in Assam, and in Cachar as compared to Darjeeling, Terai, and Western Dooars. The distribution of soils

having exchangeable potassium content above the deficiency limit of 40 p.p.m. is also interesting. In this respect

Darjeeling = Terai and Western Dooars
> North Bank
= Cachar > Eastern Dooars
= South Bank.

This distribution pattern suggests that potash response is more likely to be obtained in the Eastern Dooars than in Western Dooars, Darjeeling and Terai. To confirm this field experiments have been laid out.

Table 4(c). Regional distribution of non-exchangeable potassium.

State	Region	Non-exchangeable potassium					
		Low (0-500 p.p.m.)		Medium (501-1,000 p.p.m.)		High (> 1,000 p.p.m.)	
		No. of gardens	p.c. frequency	No. of gardens	p.c. frequency	No. of gardens	p.c. frequency
West Bengal	Darjeeling	1	4	5	20	19	76
,,	Terai & Western Dooars	1	3	17	47	18	50
,,	Eastern Dooars	9	28	19	59	4	12
Assam	North Bank	14	48	13	45	2	7
,,	South Bank	35	90	3	8	1	2
,,	Cachar	17	77	5	23	—	—

The above data suggest that Darjeeling, Terai, and Western Dooars soils are almost similar in their non-exchangeable (or potentially available) potassium contents. Further, very few soils of these regions had non-exchangeable potassium content below 500 p.p.m. Contrary to this ninety per cent of the South Bank soils are "low" in non-exchangeable potassium content (below 500 p.p.m).

Eastern Dooars soils, however, compare favourably with North Bank soils as far as this category of soil potassium is concerned, occupying an intermediate position between Darjeeling, Terai and Western Dooars soils on the one hand and South Bank soils on the other.

It is not yet known whether lack of response from applied potassium in our past trials concentrated in Western Dooars and Terai is tied up with the larger size of reserve but potentially available potassium found in these regions. However, it appears that field trials with potassic fertilizers should be located in as much numbers in the Eastern Dooars as in the Western Dooars, Terai, and Darjeeling regions, considering the distribution pattern of both exchangeable and non-exchangeable soil potassium categories.

(ii) **High level potash trials in Dooars and Terai**

Advantage was taken of the high level potash trials in the Dooars and Terai to find out the residual effects of long-term high level potash manuring on the soil potassium categories. These trials were mostly located in the Western Dooars and Terai regions, e.g., Hansqua T. E. (Terai), Kumlai T. E. (Western Dooars), Rangamutty T. E. (Western Dooars), and Dalgaon T. E. (Central Dooars). In these trials muriate of potash was applied at rates 0, 90, 180, 270, and 360 kg K_2O per hectare for a period of five years.

No significant yield benefit was recorded from potash manuring. However, there was a significant gain in both water soluble and exchangeable potassium fractions in three out of the four sites. Figures 1(a) and 1(b) show these effects on a 90 cm soil profile basis. Soil exchangeable potassium increases progressively with increasing rates of potash manuring at the three sites. This is true for the entire profile cumulatively as well as individually

for all the depths of sampling down to 90 cm, viz., at 0–15, 15–30, 30—45 and 45—90 cm. Figure 1(c) shows the effects of high level potash manuring on the exchangeable potash content of various layers of soil at Kumlai T. E. As expected, the size of the residual build up of exchangeable potash decreases with increasing depths of soils which can be seen in Fig. 1(c). However, the changes of non-exchangeable potash content with manuring were erratic.

Fig. 1(a): RESIDUAL EFFECT OF HIGH LEVEL POTASH MANURING ON THE WATER SOLUBLE K_2O CONTENTS.

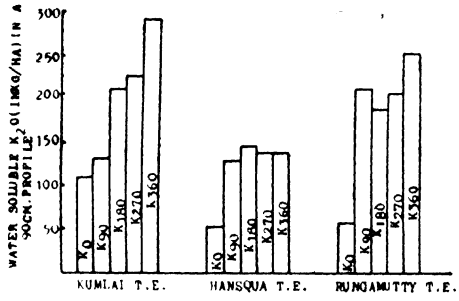


Fig. 1(b): RESIDUAL EFFECT OF HIGH LEVEL POTASH MANURING ON THE EXCHANGEABLE K_2O CONTENTS.

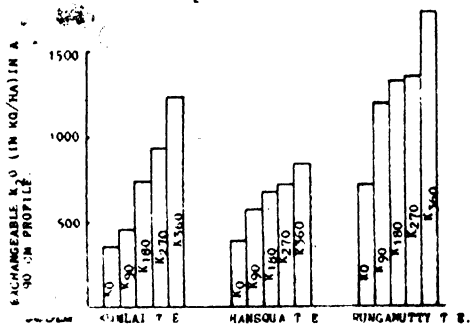
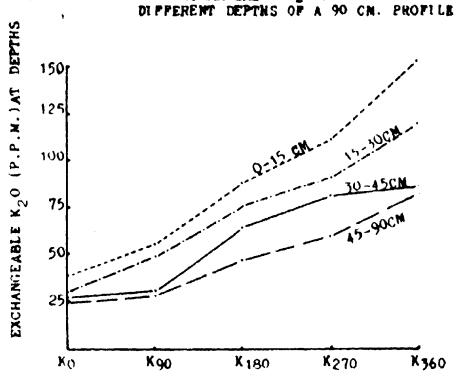


Fig. 1(c). EFFECT OF HIGH LEVEL POTASH MANURING ON EXCHANGEABLE K_2O AT KUMLAI T.E. IN DIFFERENT DEPTHS OF A 90 CM. PROFILE.



Water soluble (immediately available) and the exchangeable (available) potash fractions at all the three sites are linearly co-rrelated:

At Kumlai T. E., Y = − 19.24 + 5.08 X, significant at 0.1 % level,

At Rungamutty T. E , Y = 44.17 + 3.95 X, significant at 0.1% level,

At Hansqua T. E., Y = 29.44 + 2.46 X, significant at 5% level,

where Y = p.p.m. exchangeable potash, and X = p.p.m. water soluble potash.

This suggests that the residual build up of exchangeable potash due to high level of potash manuring in the past has been equally reflected on the labile pool where roots are directly feeding. However, it is surprising to observe that in spite of the substantial enrichment of labile potassium pool at the disposal of the roots, there was no significant increase in yield in these high level potash trials. It could be that the soil solution composition (presence of other ions) at Dooars and Terai is different from that of Assam, and plant root may fail to acquire enough potassium due to ionic competition. It was, therefore, thought necessary to determine the soil solution composition taking soils from the different tea growing regions.

(iii) **Chemical composition of soil solution**

For a balanced supply of nutrient cations from the exchange complex of a soil to the growing plant, the cationic composition of water extract from a soil (i. e. the intensity factor in the delivery of nutrients to the root surface) plays an important role. For the purpose of determining the cationic composition of soil solution, soils from fifteen tea estates in Dooars and seventeen tea estates in the South Bank were utilised. Air-dried and sieved soils were saturated to field capacity moisture levels with demineralised water in pressure plate apparatus, kept overnight, and soil solutions from saturated soils were extracted at 1/3 rd atmosphere which were finally analysed for potassium, sodium, calcium, and magnesium (i.e. the cationic compostion). Results of the analysis are given in Table 5.

Table 5. Chemical composition of soil solution.

Area	Tea district	Chemical composition, milli equivalent per 100 g soil					K/Na	K/Ca	K/Mg
		Potassium(k)	Sodium (Na)	Calcium (Ca)	Magnesium (Mg)	Total			
West Bengal	Eastern Dooars	0.023	0.122	0.018	0.004	0.167	0.19	1.28	5.75
,,	Western Dooars	0.037	0.330	0.016	0.005	0.388	0.11	2.31	7.40
,,	Central Dooars	0.020	0.205	0.014	0.004	0.243	0.10	1.43	5.00
,,	Average	0.027	0.219	0.016	0.004	0.266	0.13	1.67	6.05
South Bank of Assam	Dibrugarh	0.010	0.083	0.036	0.002	0.131	0.12	0.28	5.00
,,	Nazira	0.009	0.079	0.035	0.002	0.125	0.12	0.26	4.50
,,	Jorhat	0.013	0.051	0.049	0.002	0.115	0.26	0.27	6.50
,,	Golaghat	0.006	0.034	0.022	0.001	0.063	0.18	0.27	6.00
,,	Nowgong	0.006	0.045	0.049	0.002	0.093	0.13	0.15	3.00
,,	Average	0.009	0.058	0.036	0.002	0.105	0.16	0.25	5.00

It is seen that West Bengal soils contain almost three times total cations in the soil solution compared to the Assam South Bank soils. The increases of potassium, sodium, and magnesium in West Bengal soils compared to those in Assam have been found to be threefold, fourfold and twofold respectively. However, calcium content of soil solution in West Bengal is, on the contrary, much lower compared to those of Assam. As far as the cationic ratios are concerned, K/Na and K/Mg ratios in the two regions have been found to be practically same, whereas a large difference has been noted in K/Ca ratio. K/Ca ratio in West Bengal soils is about four times than that in Assam.

It could be that the presence of appreciably higher quantities of sodium in the soil solution under West Bengal conditions might effect availability of potassium due to ionic competition, although K/Na ratio has been found to be constant in both West Bengal and Assam. Intensive work carried out in other countries has shown that potassium availability concerns competition between potassium and other ions in soil solution (e.g. Na, Ca and Mg) for positions on the plant root than with the absolute activity (or concentration) of potassium ions in the soil solution.

Field experiments to assess the importance of ionic competition vis-a-vis potash response in West Bengal are in progress.

(iv) **Free energies of ion exchange**

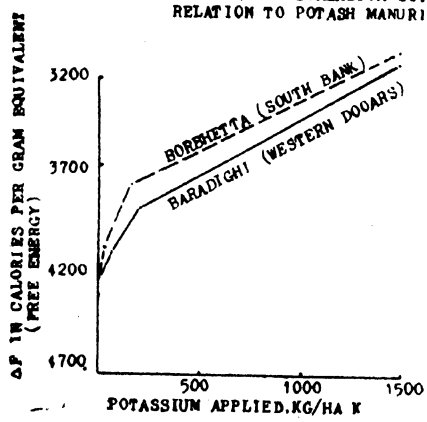
An universally applicable test for soil potassium status has not yet been devised for the entire North East India tea areas, but attempts are being made

to base soil potassium testing on a firmer and less empirical foundation. The forces with which potassium ions are held to soil colloids have not been studied in the past, but there is no reason why different soils (West Bengal and Assam) should hold potassium with the same intensity or bonding energy.

Measurement of standard free energy of ion exchange ($\triangle F = 1364 \log 1/\frac{ak}{aca}$, where ak and aca express the activities in moles per litre of potassium and calcium respectively on the equilibrium soil solution) offers us a function which is strictly based on intensity (or energy) measurement and is not tied to any arbitrarily determined category of soil potassium. Since this parameter has unequivocal significance in defining the initial ionic environment of plant roots, energy of exchange for the replacement of calcium by potassium ($\triangle$ F) has been computed from the cationic composition of water extracts of thirtytwo estate soils (eighteen from West Bengal and fourteen from Assam). Both in West Bengal and Assam, $\triangle$ F values were found to vary between limits--3,000 to—4,000 calories per g. equivalent, in spite of the differences in potassium and calcium concentrations of the soil solutions (c. f. chemical composition of soil solution reported earlier). It has been reported by earlier investigators in other countries that for balanced supply of potassium and calcium from the exchange complex of soils, energies of exchange ($\triangle$ F) should lie within limits—2,500 to—3,000 calories per g. equivalent.

The changes in energy of exchange of both Dooars (Baradighi) and Assam South Bank (Borbhetta) soils with the addition of various levels of fertiliser potash were then examined, with a view to find out whether soils of both regions show similar rate of change or otherwise of the free energy parameter ($\triangle$ F) with manuring. Results are shown in Figure 2, which suggest that the rates of change of $\triangle$ F with potash manuring at both sites are virtually same up to the maximum limit of application of 1,500 kg K/ha. It, therefore, appears that both Western Dooars and Assam South Bank soils hold potassium (native or applied) with the same intensity or bonding energy.

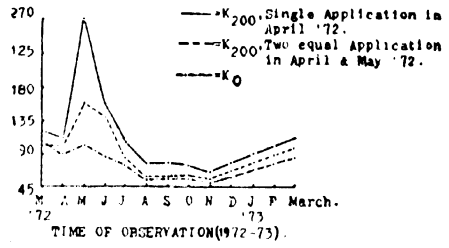
Fig.2: CHANGES IN FREE ENERGY (Δ F) OF BARADIGHI & BORBHETTA SOILS IN RELATION TO POTASH MANURING.



(v) **Seasonal fluctuation of soil potash**

Seasonal variations of soil potash in the Assam experiments have been reported in our Annual Scientific Report for 1971-72, pages 34-35. During 1972/73 top soil (0-15 cm) samples from a long term manurial trial at Baradighi T. E. were analysed at monthly intervals to determine seasonal fluctuation of exchangeable potash under Dooars conditions. Sampling was confined to top 15 cm only, since it has been observed earlier in Assam trials that changes in soil exchangeable potash follow the same trend for top and sub soils. Fig. 3 shows the trend of seasonal fluctuation of exchangeable (available) potash under Dooars conditions, both for manured and unmanured soils.

Fig 3: SEASONAL FLUCTUATION OF EXCHANGEABLE (AVAILABLE)POTASH IN DOOARS.



It is observed that during the dry period (November to March) available potash content of soil increases as has been found out in Assam (reported last year). In the manured soils peak rise takes place in May and, thereafter, a sharp decline takes place until August. Between August and November the available soil potash virtually remains unchanged. The unmanured soils also show a similar declining trend between May and August, with very little change thereafter until November.

It appears that under Dooars conditions soil sampling for available potash should best be confined to the period August to December which compares favourably with the period of sampling recommended for Assam (i.e. August to January) in the last Annual Scientific Report.

Further, for a period of four months, i.e. from June to September, soils from all the sixty-four plots of Baradighi trial were analysed for available potash both under dried and undried conditions. The dried soils consistently yielded higher values of available potash than the moist soils. The results are shown in Table 6.

It appears that for obtaining more accurate measure of potash availability, soils are to be kept moist until analysis and this is only possible by confining sampling in wet periods during August to December months.

Table 6. Increase of available potash in Baradighi experimental soils due to laboratory drying at room temperatures.

Rate of potash application	Single or split application	Percentage increase of available potash due to drying of soils
200	Single application	21
,,	Two equal application	19
,,	Four equal application	19
,,	Eight equal application	22
,,	Mean	20

Studies on liming

Long-term experiments of the Advisory Department located at Cinnamara, Meleng, and Gingia tea estates were taken advantage of to find out the physico-chemical changes in soil due to liming at the end of the experimental treatments. Results are shown in Table 7(a).

The data suggest an increasing trend of sodium, calcium, and magnesium ions in the soil exchange complex, and a decreasing trend of potassium ions. Both the percentage base saturation and the pH value increased linearly with liming, and as expected these two parameters are well correlated.

The effect of liming treatments on the cationic composition of soil solution is shown in Table 7(b).

Calcium ions in the soil solution increased significantly as a result of liming. Potassium ions, on the contrary, decreased significantly. Both the increasing effect on calcium, and the decreasing effect on potassium have been found to be progressive with the increasing rates of application

of lime. The negative relationships between calcium and potassium of the soil solution in the three liming experiments have been found to be statistically significant, and are described by the following equations :

(a) At Cinnamara T. E., $Y = 0.014 - 0.0435\ X$, $r = -0.9912$ ***

(b) At Meleng T. E., $Y = 0.016 - 0.0786\ X$, $r = -0.9062$*

(c) At Gingia T. E., $Y = 0.025 - 0.1404\ X$, $r = -0.9221$**,

where X = milli equivalent calcium per 100 g soil,

and Y = milli equivalent potassium per 100 g soil.

It appears that the displacement of potassium by added calcium from the soil exchange complex resulted in lesser competition between potassium and other ions in soil solution for positions on the plant root. As a consequence of this phenomenon, soils under limed series have been depleted in soil solution potassium either due to uptake by tea or due to losses by natural leaching process. Further studies on uptake are in progress.

Table 7(a). Changes in physico-chemical properties of soil exchange complex due to liming (data mean of three trials).

Treatments	Exchangeable cations (milli equivalent per 100 g)					Percentage base saturation of the soil exchange complex	pH (water extract)
	K	Na	Ca	Mg	Total		
T_1 : No. lime + 100 kg N/ha (S. O. A.)	0.070	0.205	0.606	0.011	0.892	22.14	4.38
T_2 : Lime 2 t/ha + 100 kg N/ha (S. O. A.)	0.080	0.240	1.740	0.035	2.095	49.02	5.12
T_3 : Lime 4 t/ha + 100 kg N/ha (S.O.A.)	0.063	0.245	2.927	0.042	3.277	69.69	6.01
T_4 : No. lime + 200 kg N/ha (S. O. A.)	0.087	0.215	0.660	0.005	0.967	24.75	4.40
T_5 : Lime 2 t/ha + 200 kg N/ha (S. O. A.)	0.073	0.220	1.326	0.022	1.641	40.52	4.89
T_6 : Lime 4 t/ha + 200 kg N/ha	0.060	0.235	2.753	0.028	3.076	74.64	5.80

Table 7(b). Changes of the cationic composition of soil solution due to liming (data mean of three trials).

Treatments	Cationic composition of soil solution (milli equivalent per 100 g)				
	K	Na	Ca	Mg	Total
T_1 : No. lime + 100 kg N/ha (S. O. A.)	0.011	0.149	0.081	0.002	0.243
T_2 : Lime 2 t/ha + 100 kg N/ha (S.O.A.)	0.009	0.153	0.124	0.003	0.289
T_3 : Lime 4 t/ha + 100 kg N/ha (S.O.A.)	0.005	0.129	0.174	0.003	0.311
T_4 : No. lime + 200 kg N/ha (S.O.A.)	0.011	0.151	0.089	0.002	0.253
T_5 : Lime 2 t/ha + 200 kg N/ha (S.O.A.)	0.008	0.148	0.106	0.002	0.264
T_6 : Lime 4 t/ha + 200 kg N/ha (S.O.A.)	0.005	0.130	0.163	0.002	0.300

Studies on soil phosphate

(i) Fractionation of soil phosphate

A wide range of variations in total and different soil phosphate fractions have been found in our preliminary study (see Ann. Rept., 1971-72, p. 33). For gaining precise knowledge, this study was, therefore, intensified during the last year, and a total of ninety soils covering both West Bengal and Assam tea districts have been fractionated for various native forms of soil phosphates.

Areas covered by the survey with sampling sites are as follows :

State	Region	Tea District	Number of sampling sites
Assam	South Bank	Dibrugarh	10
,,	,,	Sibsagar	5
,,	,,	Jorhat	8
,,	,,	Golaghat	4
,,	,,	Nowgong	3
,,	North Bank	Tezpore	7
,,	,,	Mangaldai	5
,,	,,	North Lakhimpur	3
,,	Cachar	Silchar	8
,,	,,	Karimganj	5
,,	,,	Hailakandi	2
West Bengal	Dooars	Jalpaiguri	10
,,	,,	Alipurduar	5
,,	Darjeeling & Terai	Kurseong	3
,,	,,	Darjeeling	9
,,	,,	Terai	3
		Total	90

The survey results, by and large, confirm preliminary observations given on p. 33, Ann. Sci. Rept., 1971-72. However, the main conclusions are as follows :

(a) The range of variation of total as well as different forms of soil phosphate in different regions is rather wide, and no well-marked regional distribution pattern has been found.

(b) In general, West Bengal soils are higher in total, organic, as well as various forms of inorganic phosphates. Further, the calcium phosphate fraction has been found to be much higher in Dooars than in Darjeeling.

(c) As far as the Assam soils are concerned, variations either in total or the individual phosphate fractions within the different tea districts are of little practical significance. Soils of the Mangaldai district have, however, the highest total and organic phosphate contents.

(d) Aluminium phosphate constitutes the lowest fraction of the total inorganic phosphates present in our soils irrespective of the regions.

(e) Organic and reductant soluble phosphate together constitute the major portion (about 60 per cent) of the total phosphate, although from the nutritional point of view the reductant soluble phosphate (coated with iron oxide) has no significance. Organic phosphate alone constitutes 27 to 56 per cent of the total phosphate in our soils, and can be an important potential source of phosphorus under tea growing conditions where mineralisation proceeds at a fast rate.

(f) The average percentage distribution of the three other inorganic forms of soil phosphate has been found to be:

Aluminium phosphate	:	4 – 10 per cent
Iron phosphate	:	10 – 18 ,,
Calcium phosphate	:	5 – 20 ,,

During the course of soil phosphate fractionation studies, correlations between the different phosphate fractions as well as between phosphate fractions and other soil factors were investigated. It has been found that aluminium phosphate and the "available" phosphate (determined by the Bray's extraction procedure), as well as the organic phosphate and the organic carbon are positively correlated. The relationships were linear and the goodness of fits were found to be highly significant ($P \leqslant 0.001$, $r^2 = 0.73$ between aluminium phosphate and "available" phosphate, and $r^2 = 0.70$ between organic phosphate and organic carbon).

(ii) Effect of superphosphate manuring on the soil aluminium phosphate fraction, exchangeable aluminium, and pH

Since soil aluminium phosphate and the so-called "available" soil phosphate are linearly correlated, it was considered necessary to find out what happens to the aluminium phosphate fraction with long term manuring of single superphosphate. For this purpose soil samples from

plots receiving superphosphate at various levels in two long-term N.P.K. experiments of Agriculture and Advisory Department were collected and analysed. These experiments are located at Borbhetta (B. 105) and Kalchini (D.1) representing sandy loam and silty loam types of soil respectively. Results are shown in Figure 4(a), 4(b), and 4(c).

It is seen that, irrespective of the sites, aluminium phosphate increased progressively with the increasing levels of applications of superphosphate, whereas the exchangeable aluminium content of soils shows a declining trend (Figs. 4(a) and 4(b)). The decrease of exchangeable aluminium content is further associated with an increase in pH value of soils (Fig. 4(c)).

Fig. 4(a): EFFECT OF LONG-TERM SUPERPHOSPHATE MANURING ON SOIL ALUMINIUM PHOSPHATE FRACTION.

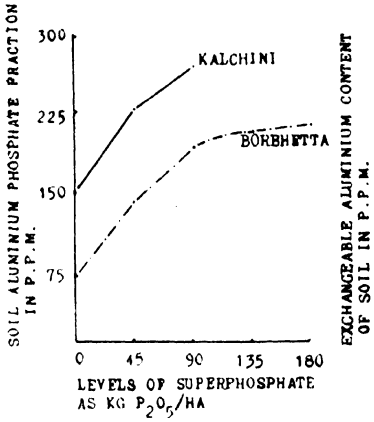


Fig. 4(b): EFFECT OF LONG-TERM SUPERPHOSPHATE MANURING ON SOIL EXCHANGEABLE ALUMINIUM CONTENT.

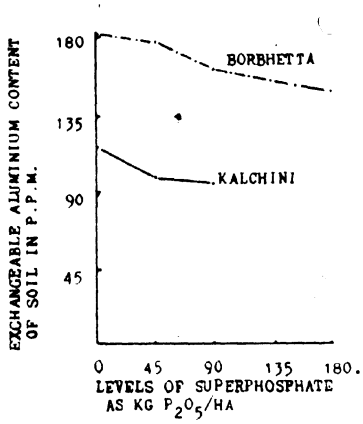
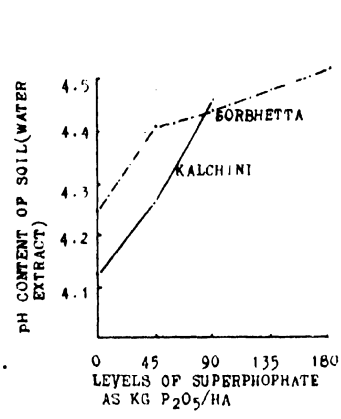


Fig. 4(c): EFFECT OF LONG-TERM SUPERPHOSPHATE MANURING ON pH CONTENT OF SOIL.



Studies on soil aluminium

Tea soils are highly acidic, and pH values as low as 3.6 are not uncommon. Although it is known that exchangeable aluminium content increases with increasing soil acidity, precise information is lacking regarding exchangeable aluminium content of tea soils and its relationship with soil pH.

Soil samples from different tea growing regions were analysed for pH and exchangeable aluminium contents, and their relationship was statistically examined. The curvi-linear regression of the soil pH values on the soil exchangeable aluminium is negative, and the goodness of fit has been found to be statistically significant ($P \leq 0.001$, $r^2 = 0.65$). The equation relating soil pH to exchangeable aluminium is:

$$Y = -0.78724 \log (X + 1) + 6.2826$$

where Y = pH value of soil water extract,

and X = soil exchangeable aluminium.

It appears that in the pH range 6.0 to 4.7 when exchangeable aluminium liberates at a slow rate (0 100 p.p.m.) the rate of decrease of pH is very fast, whereas in the pH range 4.7 to 4.1 when exchangeable aluminium liberates at a faster rate (100-550 p.p.m.) the rate of decrease of pH is rather slow. pH range 6.0 to 4.7 concerns slightly acidic soils and pH range 4.7 to 4.1 concerns highly acidic soils.

It is worth mentioning here that the exchangeable aluminium content of highly acidic soils and plucked shoots can be as high as 1,000 and 500 p.p.m. respectively. The role of aluminium in the nutrition

of tea has not yet been worked out, but the abundance of aluminium in the soil solution of highly acidic soils may have a controlling influence on the availability of phosphorus.

Studies on biuret content of Urea

Urea sources were prepared in the laboratory which contained 1, 2, 5 and 10 per cent biuret. Mature tea bushes were sprayed at fortnightly intervals with each of these sources at 4 per cent spray fluid concentration for a period of two and a half months to give a total of 75 kg nitrogen per hectare in five rounds of spray.

Mature tea leaves (4th to 6th) were plucked at an interval of one week after each spraying, refluxed for one hour with distilled water, and the infusions were analysed for biuret content. Biuret could not be detected in the infusion even after five rounds of spraying. Toxicity symptoms could not also be detected in the field.

Further, this investigation was extended to find out whether presence of biuret in urea exerts an inhibitory effect on the absorption of nitrogen (from urea) by tea plant. For this purpose 4 per cent solutions of urea containing 0,1,2,5 and 10 per cent biuret were rubbed on both surfaces of third leaves of young shoot of a tea bush for a period of one week. After a week these leaves as well as urea untreated leaves of same age were collected from the same bush, washed thoroughly to remove unabsorbed surface urea, and their nitrogen contents determined. Results are given in Table 8.

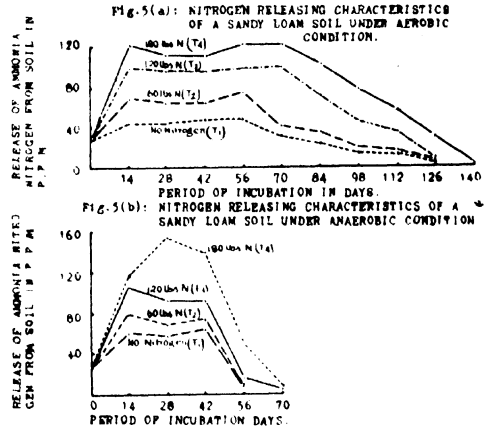
Table 8. Nitrogen content of third leaf of young shoot treated with urea solutions of varying biuret contents.

Treatments	Details	Percentage nitrogen on dry wt. basis
T_1	Not treated with urea	2.73
T_2	Treated with 4% urea solution (biuret traces)	3.18
T_3	Treated with 4% urea solution, containing 1% biuret	3.16
T_4	Treated with 4% urea solution, containing 2% biuret	3.08
T_5	Treated with 4% urea solution, containing 5% biuret	3.24
T_6	Treated with 4% urea solution, containing 10% biuret	3.28

From the above observations, it appears that the total quantities of biuret supplied to tea through foliar spray are insufficient either to produce visible toxicity symptoms or to inhibit nitrogen absorption from applied urea. Further studies are planned on the effect of biuret contamination on nitrogen utilisation by tea.

Studies on soil nitrogen

Nitrogen releasing characteristics of a sandy loam soil at various levels of nitrogen fertilisation have been studied in the laboratory utilising both aerobic and anaerobic incubation techniques. The fertiliser nitrogen treatments were no nitrogen (T_1), 60 kg N/ha (T_2) 120 kg N/ha (T_3), and 180 kg N/ha (T_4). Ammonia and nitrate nitrogen in soil were estimated at fortnightly intervals for a period of about two and five months for anaerobic and aerobic incubation respectively. There has not been any significant variation in the nitrate release from soil under any of the treatments over the period of five months aerobic incubation. For anaerobic incubation, however, the release of nitrogen from soil will only be in the form of ammonia. The results are shown in Figs. 5(a) and 5(b).



It appears that peak mineralisation of applied or native nitrogen takes place within two weeks under aerobic condition (Fig. 5(a)). Subsequently, release at this peak rate continues up to eighth or

tenth weeks for low and high levels of nitrogen fertilisation respectively. Thereafter, the rate of release steadily declines becoming negligible at the end of 3, 4, and 4½ months for 60, 120 and 180 kg N/ha respectively.

The pattern of ammonia release under anaerobic condition suggests that mineralisation peak is also reached within 2-3 weeks as has been found with aerobic incubation, but the release is not sustained for a long period (Fig. 5(b)). In fact in about two to two and a half months time release becomes negligible.

Considering the growing season of tea in North East India (about nine months) and the pattern of mineralisation of applied or native nitrogen under both well-drained (aerobic) and water-logged (anaerobic) conditions, it appears that nitrogen availability is not sustained.

Further studies on nitrogen uptake by tea in relation to its availability in soil are in progress.

Residue test for weedicide

The arsenic residue problem in tea flushes and soils due to application of Ansar 529 (MSMA) as a chemical weed-killer was investigated. The Silver diethyldithiocarbamate (SDDC) method was adopted for the determination of arsenic. Arsenic generators, as required by this method, have been designed and fabricated locally. The standard curve for trace arsenic analysis methanearsonic acid (MSMA) was established by absorptiometry at 540 mμ'. The lower limit of detection was found to be 0.25 μg of As or 0.05 p.p.m. for a 5 g sample. The percentage recovery of added arsenic by this method has been shown in Table 9.

Table 9. Arsenic recovery by SDDC method.

Micro-gram arsenic added (as trioxide) to dried & powdered tea leaf sample	Micro-gram arsenic recovered	Percentage recovery
0.50	0.45	90.0
1.50	1.35	90.0
2.00	1.75	87.5

Altogether three hundred and seven tea samples from different field experiments with Ansar 529 have been analysed for arsenic residues. The results suggest that there was practically no residue build up of arsenic in plucked tea after one year's use of Ansar 529.

SOIL PHYSICS

Drainage investigations

(i) Soil texture and Permeability

Preliminary results of reconnaissance texture survey carried out in the South Bank of Assam have been reported last year (Ann. Sci. Rept., 1971-72, p. 37). The survey was intensified and extended to cover all the tea growing regions of North East India with an aim to determine the frequency distribution of different texture classes. For this purpose samples were drawn from one hundred and thirtynine tea estates with the following distribution pattern :

State	Region	No. of estates
Assam	South Bank	45
,,	North Bank	25
,,	Cachar	18
West Bengal	Dooars	33
	Darjeeling & North Terai	18

On the basis of the results of texture analysis, percentage frequency of occurrence of the various texture classes were calculated which is shown in Table 10.

Table 10. Percentage frequency of occurrence of different texture classes in North East India tea areas.

Tea Area	Texture classes (data in percentages)				
	Loamy sand	Sandy loam	Loam	Silt loam	Silty clay loam
North East India	7	32	22	36	3
Assam	2	38	22	33	5
West Bengal	16	22	20	42	nil
South Bank	nil	33	25	42	nil
North Bank	8	48	20	24	nil
Cachar	--	34	22	22	22
Dooars	6	16	19	59	nil
Darjeeling and North Terai	35	35	20	10	nil

It is seen from the survey data that the majority of tea soils in North East India belong to the three main textural types viz, sandy loam, loam and silt loam. However, certain regional characteristics have been observed which are :

(a) Occurrence of sandy type (loamy sand and sandy loam) of soils in larger proportion in North Bank than in South Bank, which could be due to the existence of Bishnauth sand series.

(b) Occurrence of a fairly good percentage of silty clay loam type of soils in Cachar besides the three main textural types. This could be due to the presence of so-called clay flats.

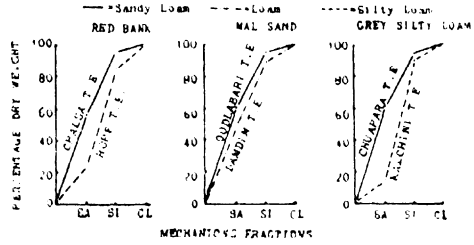
(c) Occurrence of a large percentage of silt loam type of soils in Dooars.

(d) Occurrence of a very large percentage of sandy type (loamy sand and sandy loam in equal proportion) of soils in Darjeeling and North Terai.

In Memorandum No. 28 on drainage of tea soils, five arbitrary texture classes have been considered in the absence of precise data on the textural properties of N. E. India tea soils. It may be possible to determine both vertical intervals of contour drains for safe disposal of storm water and, horizontal spacing of additional contour drains to control water table on the basis of only three main textural types which cover majority of our tea areas.

Further, the present survey suggests that classification of soil series is more important than accepting the so-called soil types (enunciated by H.H. Mann) for drainage purpose. The summation curves prepared from texture data of soils belonging to Mann's type like Red Bank (Dooars), Mal sand (Dooars), and Grey silty loam (Dooars) are presented in Fig. 6. The curves show that within a soil type there may be considerable variations in the distribution of the mechanical fractions like sand, silt, and clay, which calls for identification of soil series through large-scale survey.

Fig.6: SUMMATION CURVES OF TEXTURE DATA FROM DIFFERENT SOIL TYPES



Preliminary results on the permeability of South Bank soils and horizontal spacing between the two subsidary drains have been reported last year (Ann. Sci. Rept., 1971/72, p. 38-39). This work was further extended to cover as much tea areas as possible with a view to establish permeability range for individual textural types, as well as to verify the validity of the drain spacings given earlier (Ann. Sci. Rept., 1971/72, p. 39) based on the South Bank data.

For this purpose about twenty estates under each texture class were randomly selected covering the entire tea growing regions of N. E. India and tested for permeability. Results are given in Table 11.

Table 11. Permeability range of tea soils (K data expressed as meter per day where K = permeability).

REGIONS	Textural types							
	Loamy sand		Sandy loam		Loam		Silt loam	
	No. of estates	Range of K	No. of estates	Range of K	No. of estates	Range of K	No. of estates	Range of K
South Bank (Assam)	5	1.40—3.75	8	0.89—1.19	5	0.63—0.74	5	0.30—0.52
North Bank (Assam)	5	1.78—3.14	6	0.89—1.25	5	0.57—0.75	5	0.24—0.30
Cachar (Assam)	1	2.64	5	0.90—1.26	3	0.57—0.74	2	0.21—0.45
Dooars (West Bengal)	3	1.43—2.23	4	0.85—1.29	4	0.57—0.75	8	0.15—0.51
Darjeeling and North Terai(West Bengal)	10	1.35—4.16	3	1.05—1.20	2	0.65—0.74	1	0.51

The range of permeability between regions under any one texture type does not practically vary and, as such, mean values of permeability for each texture class can be accepted with reliability for determination of horizontal spacing of field or secondary drains to control water table. Mean values of permeability in m/day have been calculated as 3.40, 1.06, 0.67, and 0.35 for loamy sand, sandy loam, loam, and silt loam respectively which compare favourably with South Bank data reported earlier (Ann. Sci. Rept., 1971/72, Table 6, p. 39).

(ii) **Run-off and Erosion studies**

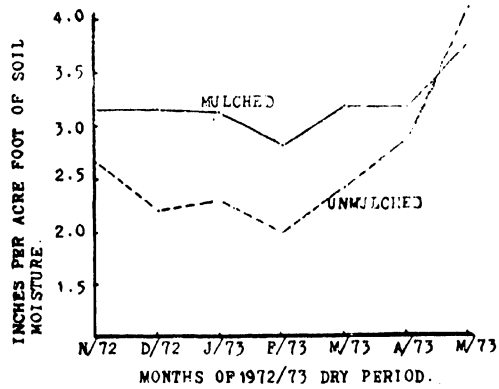
Soil and nutrient losses from erosion plots of different slopes have been reported last year (Ann. Sci. Rept., 1971/72, p. 40). Run-off measurements were recorded throughout the wet period of 1972 at both Tocklai and Nagrakata with a view to establish relationship between slope, rainfall intensity, and the total run-off. The relationships have been found to be inconsistent indicating a need to improve our technique of measurement for which automatic run-off recorders have to be procured.

However, advantage was taken during 1972/73 dry period to find out the differences in moisture content of 30 cm soil profiles in mulched and unmulched plots. Results are shown in Fig. 7. It is seen that the mulched plots had about 0.8 inches per acre foot more moisture than the unmulched plots during the rainless period of January to March, 1973.

Studies on water table

It has been mentioned in Ann. Sci. Rept., 1971/72, p. 44, that observations on the growth of tea and, physico-chemical changes of soil in experimental tanks, where water tables have been kept fixed at 45, 90 and 135 cm, are progressing. Some of the interesting observations are given below :

Fig. 7: MOISTURE CONTENT OF MULCHED AND UNMULCHED PLOTS DURING 1972/73 DRY PERIOD.



(a) Yield : Data on the relationship between yield and depth of water table are shown diagramatically in Fig. 8(a). It is clearly seen that when water table is kept fixed at 45 cm from the surface, yielding capacity of the tea bushes, irrespective of the clonal difference, tails off very significantly as compared to those bushes which are grown with water tables either at 90 or 135 cm from the surface.

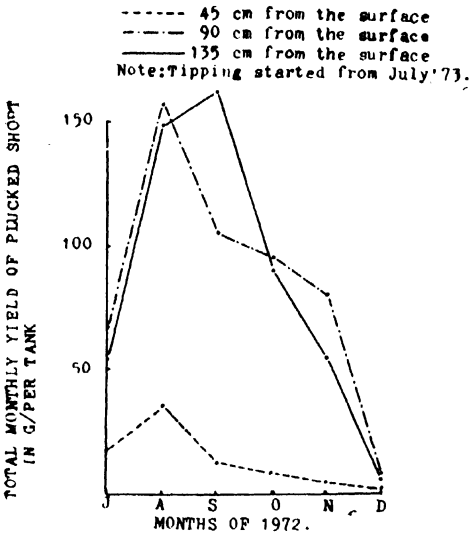
(b) Nutrients : It appears that reduced soil conditions, when water table is fixed at 45 cm from the surface, results in decreasing the acidity status of soil layers above the water table. This could be due to the liberation of ammonia from applied or native nitrogen sources.

As far as the nutrient changes are concerned, it appears that:

(i) nitrate content of each 15 cm layer of soil down to 45 cm increases with the increasing depth of water table from the surface. It can, therefore, be inferred

that with good drainage (i.e. increased depth of water table) nitrifi-cation will be encouraged.

Fig. 8(a): RELATIONSHIP BETWEEN YIELD AND DEPTH OF GROUND WATER TABLE EXPERIMENTAL TANKS.

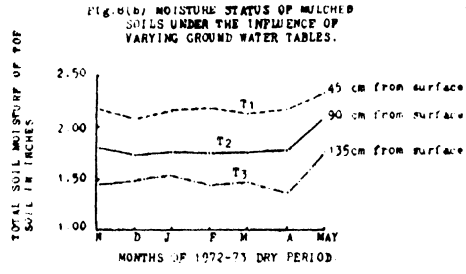


(ii) it appears that under reduced soil conditions phosphate solubility increases, and, as a result, more soil phosphate is leached out of the root zone.

(iii) it appears that under reduced soil conditions exchangeable manganese increases and, exchangeable aluminium decreases. The increase of exchangeable manganese could be due to the reduction of reducible manganese fraction of soils which is normally unavailable. The decrease of exchangeable aluminium is tied up with the reduction of soil acidity.

(c) Moisture : Experimental tanks were mulched in October, and the influence of fixed water tables on the top soil moisture content was followed at weekly intervals during the dry period of 1972-73 both by the gravimetric and the tensiometric procedures. Fig. 8(b) shows the moisture status of mulched soils under the influence of varying ground water tables. It appears that surface mulching resulted in minimum depletion of top soil moisture, irrespective of the depths of water table, during the dry period (i.e. between December and April). However, direct, contribution of moisture from the ground water table to the surface soil has been found to be remarkable, for example, at the end of the dry period, i.e. in April, soil water content increases by 0.4 inches per acre for every 45 cm rise in ground water table.

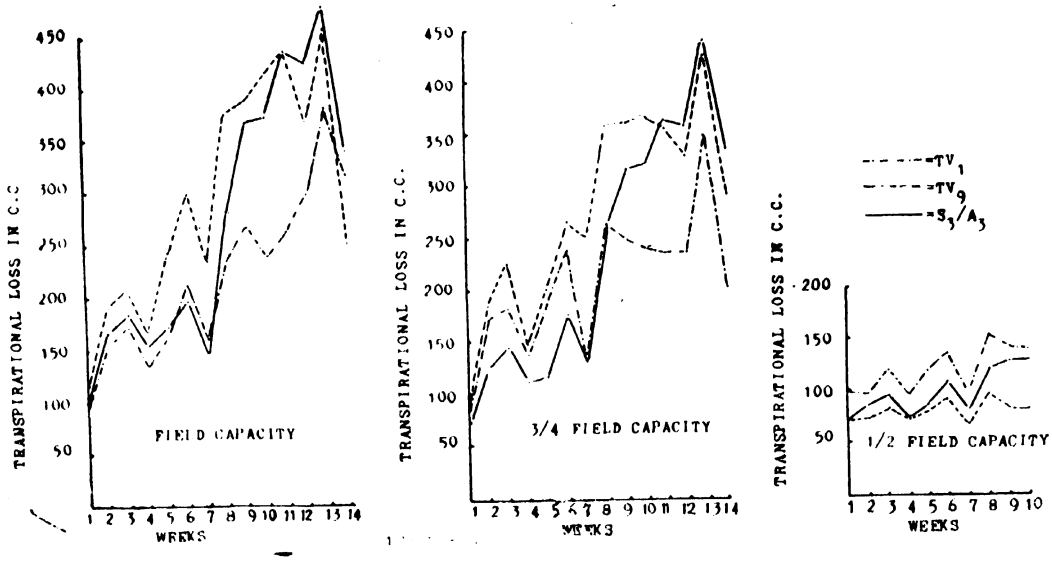
Fig. 8(b) MOISTURE STATUS OF MULCHED SOILS UNDER THE INFLUENCE OF VARYING GROUND WATER TABLES.



Studies on transpiration

Transpirational losses of soil water by clonal tea was estimated using sleeved plants which were maintained at three moisture regimes viz., field capacity, 3/4th field capacity, and $\frac{1}{2}$ field capacity. For this purpose two year old TV_1, TV_9 and S_3/A_3 (Jorehaut Tea Co. clone) clones were used. Weekly transpirational loss per plant was recorded during the dry period from January to April, 1973. The pattern of transpirational losses of soil water by clones under different moisture regimes, as indicated by this preliminary study, is shown in Fig. 9. It appears that clone TV_9 transpires significantly higher quantities of water than TV_1 or S_3/A_3 when the soil remains sufficiently moist, but the reverse is true when soil is fairly dry. Clone TV_1 appears to behave in the opposite way. It is therefore expected that TV_1 will resist drought for a longer period than TV_9.

Fig. 9: TRANSPIRATIONAL LOSS OF SOIL WATER BY CLONES AT DIFFERNT MOISTURE REGIMES.



Measurement of soil moisture

The regression of tensiometer readings (y) on soil moisture (X) is given by the equation y = 63.425 − 2.396 X. Based on this equation, the range covered by the tensiometer between tensions of 0 and 30 cm of mercury extends from 26.48 per cent to 15.00 per cent of soil moisture, an absolute range of 11.48 per cent.

Summary of Meteorological data

Meteorological conditions in ten-day units have been given for 1972 for all the four meteorological sites, and a summary of the observations for 1972 is given in the appendix.

A new meteorological sub-station has been set up in the North Bank Advisory head quarters and, an advisory assistant has been trained up for recording daily meteorological observations from the begining of 1973.

Research and advisory analysis

About 44,000 soil analysis have been carried out during the year. The break-up is as follows :

(i) **Research :** For Soil Department's as well as for other Departments, 10,200 estimations.

(ii) **Advisory :** For tea estates alone, 33,800 estimations.

Botany Department

PLANT IMPROVEMENT

Production of clonal seed

Seven micro seed-baris of biclonal combinations established in 1969 (Ann. Rep. 1968, p. 50) produced small quantities of seed in 1972. Seeds harvested from these baris were planted in the nursery for observing percentage germination, uniformity of growth and vigour of the seedlings. The seedlings will be planted out for trial in autumn 1972. Seeds from these stocks will be distributed next season for district trials in different agro-climatic regions of North East India.

Initial observation on the compatibility and seed yield pattern of the seed baris indicate satisfactory production of viable seeds under natural conditions by all the clonal combinations.

Pollination programme

Under the pollination programme undertaken to screen good combiner clones and select outstanding bushes as vegetative clones from the segregates (Ann. Rep. 1971-72, p. 45), a series of crossings were done using TV 1 and TV 9 as the female parents and 15 other clones as pollen parents. As the plants used for pollination are still very young, only 1526 pollinations could be done in 17 different crosses. Per cent fruit set by end April varied from 0 to 52.6 per cent, the average for the 17 crosses being 23.7 per cent. In most of the crosses the percentage set was satisfactory, except in the cross between TV 1 × TV 8. Causes for failure in this cross are under investigation.

In the hand-pollination programme for production of high quality triploids, crosses were made using seven natural tetraploids as the female parent. About 757 pollinations were done in 18 crosses using three diploid clones as pollen parent. Initial observation shows satisfactory fruit-set in most of the crosses. Details are given in Table 1.

Table 1. Preliminary results of hand-pollination for production of triploids from crossings between diploid and tetraploid clones.

Crosses (Tetraploid × Diploid)	No. of flowers pollinated	Fruit set (as on 30th April, 1973)	Per cent fruit set
398/1 × TV 1	36	0	0
TV 3	34	2	5.9
TV 7	85	0	0
398/2 × TV 1	109	63	57.8
TV 3	91	51	56.1
TV 7	100	47	47.0
398/3 × TV 1	12	3	25.0
TV 3	4	2	50.0
TV 7	34	4	11.8
398/4 × TV 1	69	40	58.0
TV 3	32	20	62.5
TV 7	54	26	48.1
398/9 × TV 1	22	15	68.2
TV 3	22	12	54.5
TV 7	50	35	70.0
398/11 × TV 1	27	12	44.4
398/21 × TV 1	25	5	20.0
TV 3	11	0	0
Total	757	337 Average	44.5

Release of vegetative clone

One more clone, TV 19, was released to the Industry during the year.

TV 19 is a yield clone, drawn from the same series as TV 18, having similar growth habit and yield potential (Ann. Rep. 1970-71, p. 43), but

with a more spreading frame and bigger leaf-size. The clone possesses better cup-characters than the other popular yield clones TV 9 and TV 18, and is suitable for both C. T. C. and Orthodox manufacture.

Clone TV 20 has also been selected for release towards the early part of 1974.

Selection of vegetative clones

About 44 bushes from different hybrid jats, biclonal and polyclonal progenies were selected during the season for rooting and long-term trials.

Long-term trial of clones

The long term trial started in 1970, in which nine clones are under trial, produced sufficient quantities of leaf during the year for manufacture in 1 kg rollers. Samples were tasted by Tocklai, Calcutta and London panel of Tasters.

Tasters varied considerably in their assessment of the teas from both C.T.C. and Orthodox manufacture. Considering both yield and Tasters' valuation, three clones appear to be promising. The trial will be continued for a few more years before final selection.

The three long-term trials planted in autumn 1971 are expected to produce sufficient leaf for manufacture in 1973.

Out of the Long Term trials now completed, two clones have been found promising and are earmarked for release in the near future.

Induction of Mutation

A few seeds were obtained from pollination carried out with x-irradiated pollen (Ann. Rep. 1970-71, p. 43), out of which one of the seedlings has shown extreme vigour of growth with good branching habit in comparison with the other normal seedlings of the same nursery. The plant is suspected to be a mutant (Plate 1) and cytological investigations are being conducted for confirmation. As soon as sufficient shoots become available, the plant will be vegetatively multiplied for planting trial plots to evaluate its cup characters and yield potential.

Plate 1. One year old seedling from seeds obtained from flowers pollinated with X-irradiated pollen.

In order to investigate the suitable dosage of irradiation for tea seeds and single-node cuttings used for vegetative propagation, a small amount of seed from Tocklai biclonal stock 449 and cuttings of clones TV 1, TV 9 and TV 18 were irradiated with different dosage of x-rays ranging from 2 kr to 10 kr at Jute Agricultural Research Institute, Barrackpore. Preliminary results are presented in Tables 2 and 3.

Table 2. Germination of stock 449 seeds irradiated with x-rays.

Dosage	No. of seeds treated	No. of seeds germinated	Percentage germination
Control	102	50	49.0
1 kr	78	31	39.7
2 kr	90	44	48.8
4 kr	108	12	11.8
6 kr	78	10	12.8

Table 3. Percentage survival of cuttings irradiated with different dosage of x-rays, 6 months after planting.

Clone	Irradiation dosage				
	2 kr	4 kr	6 kr	8 kr	10 kr
TV 1	50	10	10	30	0
TV 9	25	15	30	55	20
TV 18	80	35	35	30	10

The figures for per cent germination of the irradiated seeds suggest that tea seed can tolerate dosage of X-rays upto 6 kr although percentage germination declined sharply with the increase of dosage beyond 2 kr.

In case of clonal cuttings, TV 1 and TV 18 showed gradual decline in percentage survival with the increase in the dosage of irradiation, while in the case of TV 9, good percentage of survival was obtained even when the cuttings were exposed to a dosage of 8 kr. Further observations will continue.

PLANT PHYSIOLOGY

Transpiration studies

In view of the sudden interest shown by some tea estates in the complete removal of shade trees, an experiment was carried out to determine transpiration rates of potted plants under conditions likely to be applicable to large areas of tea in N.E. India. We have demonstrated that with tea plants of the correct leaf pose under non-limiting water and nutrient regimes, shade is not required for tea, but these conditions are rarely fulfilled in many plains districts of N. E. India. In the cold weather it is water shortage rather than excessive leaf temperature which is a limiting factor and the experiment was designed to compare transpirational losses under both high and low soil moisture status *viz.* 20% moisture content (field capacity) and about 10% moisture content.

Plants were sealed in alkathene bags after watering to the required level and half were placed under overhead shade allowing about 40% incident radiation, the other half being in full light. The bags were covered to prevent the soil heating up and all plants were weighed daily. The amount of water lost was replaced daily to maintain soil moisture levels and leaf areas of all plants were determined at frequent intervals. All major meteorological factors were measured daily including maximum and minimum temperatures, relative humidity, hours of sunshine and rainfall. Water loss may be expressed as either the total amount per plant or, to simplify the presentation of the data, as the weight of water per unit area of leaf surface. Fig. 1 shows the results of a 20 day period in early December for all four treatments.

Although daily losses show considerable variation it is apparent that whether shaded or not, at field capacity the plants lost more moisture than at lower moisture status. From 14 to 17 days plants under shade lost more water than in full light and this was due to mid-day stomatal closure in the unshaded plants during a period of very low relative humidity.

For the 50% field capacity series the unshaded plants always lost more moisture than the shaded plants except on dull, humid days when the losses were about equal. Over a period of a month the total moisture loss was almost 50 per cent greater for the unshaded plants.

There are obvious criticisms against extrapolating such experimental findings to field conditions but on the other hand there are some similarities between the experimental design and the field conditions of young tea plants. In the experimental design no moisture loss by evaporation can occur and the

FIG. 1

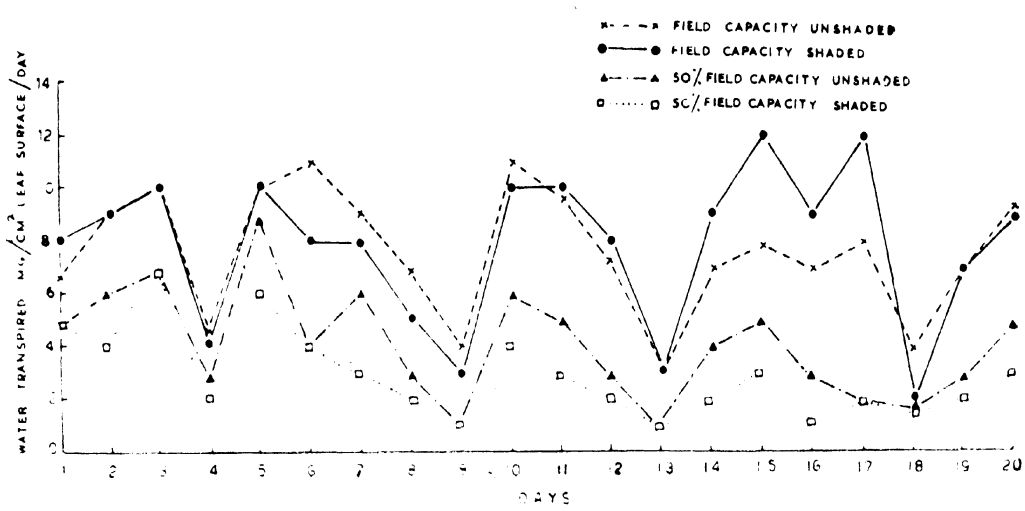


Fig. 1. Rate of transpiration per unit leaf area per day under different field conditions.

roots are restricted to the depth of the pots, in this case, about 22.5 cm (9"). In the case of mulched young tea evaporation losses are small and root depth is about the same as in the pots. The major difference is that soil moisture is rarely maintained at the same level under field conditions during the cold weather and a falling water table plus transpiration losses results in considerable moisture stress in most areas of N. E. India. To observe the effects of increasing water stress two sets of sleeve-grown plants were watered to field capacity and sealed. One set of plants was kept under shade and the other set was left in full sun. The plants were weighed daily and water losses were not made up by watering. Results for a 30 day period are shown in Fig. 2.

FIG. 2

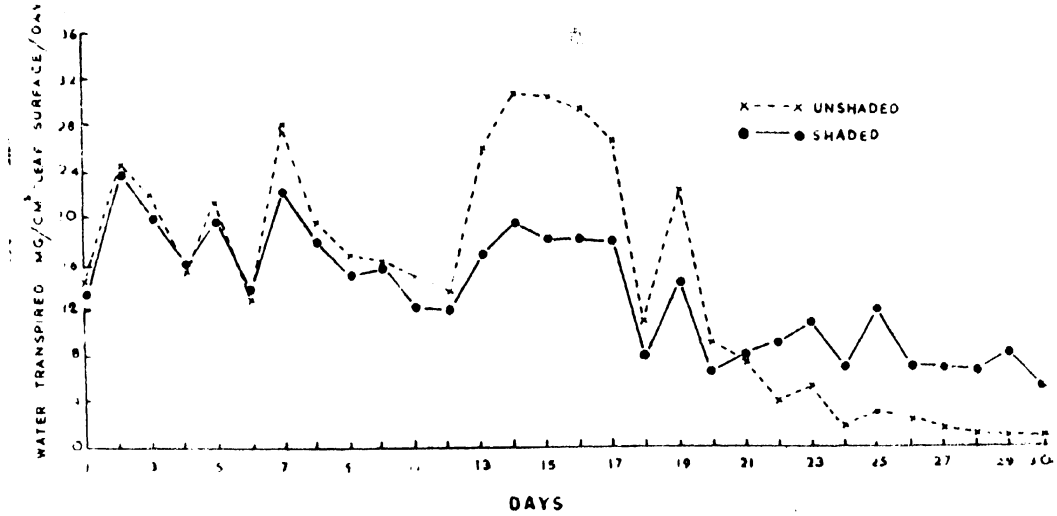


Fig. 2. Rate of transpiration per unit leaf area per day with increasing water stress under shaded and unshaded conditions.

Both shaded and unshaded plants lost moisture at about the same rate initially but as the soil moisture level fell, the unshaded plants lost progressively more, especially during the period of bright days marked on Fig. 2. From day 19 temporary wilting symptoms were seen in the unshaded plants and shortly after this the rate of water loss fell below the shaded series and the plants started to defoliate. By day 30 the soil moisture level had fallen to 7% compared to 9.5% in the shaded series, which had also started to exhibit temporary wilting by this time.

In field practice the difference between survival and death due to drought is often the matter of a few days and this fact has been strikingly demonstrated in middle and lower Assam and West Bengal in early 1973 where many thousands of young plants have died through a drought, which, though severe, is certainly not exceptional. In almost all cases the affected tea had either been unshaded or so poorly shaded that shade was ineffective.

The adoption of practices followed in climatically better situated areas to areas prone to drought has been partially responsible for this situation. The experiment described above give a simple demonstration that unless one is assured of adequate soil moisture, either naturally or by irrigation, young tea should be planted under a light, even stand of shade.

Leaf Surfaces

During investigations on the spectral properties of tea leaves, Professor J. P. Hudson kindly offered the use of the Stereoscan Electron Microscope at Long Ashton Research Station, Bristol, England, to photograph leaf surfaces.

Remarkable differences between the surfaces of leaves from various types of tea bushes were found and an example is given in Plates II and III, below.

Plate II. Electron photomicrograph of the upper surface of the leaf from a broad-leaf Assam variety.

Plate III. Electron photomicrograph of the upper surface of the leaf of a hybrid variety.

Plate II is the upper surface of a young (3 month old) leaf from a broad-leafed Assam variety and Plate III is an older (9 month old) leaf of a more hybrid type. The surface of the leaf in Plate II is very smooth while that in Plate III is overlaid with many growths of crystalline wax. Such structures are rarely found in plants growing at high temperatures and would therefore appear to be a feature of the "China" influence in hybrid types. Waxy surfaces are notoriously difficult to wet and the implications for pest and disease control vis-a-vis the use of wetting agents and stickers may be important, especially as the lengthening of pruning cycles results in more older leaves remaining on tea bushes now than in the past.

Trace elements for tea

Preliminary trials in Tocklai area 2A during 1967 suggested that tea bushes looking apparently healthy may benefit from certain micro-nutrients like zinc and manganese. Trials carried out at Borbhetta in 1969 and 1970 (Two and A Bud, Vol. 18, 1971, p. 57) and single plot trials of the Advisory Department in 1971 showed zinc to have beneficial effect on yield while the effect of manganese was much less pronounced. In the light of these observations, a statistically designed experiment was conducted during 1972 in a neighbouring estate, in which aqueous salt solutions of zinc, manganese, molybdenum and boron, alone and in combinations, were sprayed on tea bushes under plucking. Soil application of magnesium was another treatment of the experiment which was conducted in a replanted site on seven years old bushes of Stock 203 yielding about 1100 kg made tea per hectare. The yields of the experimental plots were recorded at weekly rounds by trained personnel from this Department. These results were reported in Two and A Bud, Vol. 19(2), pp. 63-65, December 1972.

Zinc application increased yield significantly (by 20 per cent) while the effect of other elements was not significant. These results clearly show that application of zinc would be beneficial to poor, replanted areas of tea and perhaps to other poor areas. It is, however, essential that responses to this element should first be ascertained by estates themselves through small-scale observation trials before adopting application on a wider scale.

Even in the very first year, the control plots of the experiment gave 18 per cent increase in yield over the estate controls in the same section of tea situated alongside the experimental plots. Drainage and weed control in the experimental area were somewhat better than in the adjoining part of the section where the estate controls were located. The experimental plots were manured with NPK at 150, 40 and 80 kg/ha while the estate controls received only nitrogen at 100 kg per hectare. This striking increase in yield of the experimental control is a clear demonstration that vast improvement in the yield of poor sections of tea is possible if attention is paid to normal agronomic practices. It was, therefore, pointed out in the article under reference that mere application of zinc without correcting the other causes of debility of a section of tea could not be expected to produce the desired effect.

Further experiments are in progress in the same estates to compare the effects of soil versus foliar and annual versus biennial application of zinc and other micro-nutrients.

Shade X nutrient X clone trial

A description of this trial first appeared in Tocklai Ann. Rep. for 1962, pp. 26-28 and short progress reports in subsequent years (Annual Report for 1964, 1965, 1966, 1968-69, 1969-70 and 1971-72). The experiment was started in 1958-59 and terminated in 1969 and one entire block of the trial, including the shade trees, was uprooted in early 1972. A brief description of the trial for ready reference and a few important results are given below.

Description of the trial

The trial was started in Tocklai area II to observe the effect of mechanical bamboo screen shade and shade from *Albizzia chinensis* trees on growth and yield of clonal tea in the presence and absence of inorganic nitrogen and organic leaf litter of shade trees. Twenty five clones were taken at random

from five different *jats* representing almost the entire range of forms cultivated in the plains of North East India. Each one of the 25 clones were planted in 27 strips, in 3 repeats of 9 strips each. In every strip, a clone was represented by a row of 5 bushes, spaced 45 cm × 60 cm, the total number of bushes in a strip being 135 including the two guard rows of 5 bushes each planted with clone TV 1. A repeat was first split into 3 sub-blocks for mechanical shade, tree shade and no shade i.e. full sun. The three strips in a sub-block were allocated to the following manurial treatments :

1. Control i.e. no manure.
2. Nitrogen applied as ammonium sulphate in March/April @ 112 kg N/ha.
3. Removal or addition of shade tree droppings.

Shade tree droppings were collected from a strip under *A. chinensis* trees and mixed with an equal quantity of litter collected elsewhere. One half of this was applied to a strip under the bamboo screens and the other half to a strip in full sun. This procedure was repeated for all three repeats of the trial.

Bamboo screens with side walls transmitting approximating 50-60 per cent of the incident light were erected prior to the planting of tea in 1958-59. *A. chinensis* trees were planted at the same time as the tea bushes, 3 m apart. To maintain the same light intensity from the beginning, *Crotalaria anagyroides* plants were also grown one year prior to planting tea bushes and kept lopped. These were removed gradually in the following year when the *A. chinensis* trees started giving shade. In subsequent years the shade under the *A. chinensis* trees was controlled at 50-60 per cent of full sunlight, either by lopping or removing trees whichever was necessary. Nitrogen and shade tree droppings were applied to the relevant plots since 1962. Until then plants were not manured at all, not even at the time of planting.

The tea bushes were pruned and plucked at lower levels, so that even after 12 years the frame height was only 50 cm and the plucking height 70 cm above the ground level. By 1963, it was apparent that the spacing was too close even for such low bushes and alternate rows of bushes were removed just below the ground level to space them out to 60 cm × 90 cm.

As no significant effect of nitrogen alone was observed in any of the treatments, phosphate and potash were applied from 1965 and magnesium and other nutrients in the subsequent years. The manuring schedule since 1962 is given in Table 4.

Table 4. Manuring schedule of the experimental plots since 1962.

Year	Tree			Screen			Sun		
	Treatments			Treatments			Treatments		
	1	2	3	1	2	3	1	2	3
1962 to 1964	+L	C	N_{100}	+L	C	N_{100}	+L	C	N_{100}
1965	-L	C		+L			+L		
	$P_{80}K_{80}$		$N_{100}P_{80}K_{80}$		$P_{80}K_{80}$	$N_{100}P_{80}K_{80}$		$P_{80}K_{80}$	$N_{100}P_{80}K_{80}$
1966	-L	C		+L			+L		
	$P_{80}K_{80}Mg_{20}$		$N_{100}P_{80}K_{80}Mg_{20}$		$P_{80}K_{80}Mg_{20}$	$N_{100}P_{80}K_{80}Mg_{20}$		$P_{80}K_{80}Mg_{20}$	$N_{100}P_{80}K_{80}Mg_{20}$
1967	-L	C		+L			+L		
	$P_{80}K_{80}Mg_{20}Zn_{10}B_5Mb_5Mn_5$		$N_{100}P_{80}K_{80}Mg_{20}Zn_{10}B_5Mb_5Mn_5$		$P_{80}K_{80}Mg_{20}Zn_{10}B_5Mb_5Mn_5$	$N_{100}P_{80}K_{80}Mg_{20}Zn_{10}B_5Mb_5Mn_5$		$P_{80}K_{80}Mg_{20}Zn_{10}B_5Mb_5Mn_5$	$N_{100}P_{80}K_{80}Mg_{20}Zn_{10}B_5Mb_5Mn_5$
1968	Litter not removed	C	$N_{100}Zn_{10}$	Litter not added	Zn_{10}	$N_{100}Zn_{10}$	Litter not added	Zn_{10}	$N_{100}Zn_{10}$
1969	Litter not removed	C	$N_{100}P_{40}K_{40}$	Litter not added	N_{100}	$N_{100}P_{40}K_{40}$	Litter not added	N_{100}	$N_{100}P_{40}K_{40}$

Note : - L : Litter removed; + L : Litter added; C : Control plots (no manure); N : Nitrogen; P : Phosphate as P_2O_5; K : Potash as K_2O; Mg : Magnesium as MgO; Zn : Zinc; B : Boron; Mb : Molybdenum; Mn : Manganese. The quantities of nutrients added in kg per hectare are shown as suffixes 100, 80, 5 etc.

The plots were light pruned every year except in 1968 when they were left unpruned.

Results

Yields under tree, screen and sun for the years 1964-69 are given in Table 5. Yields till 1963 have been left out of the table as bushes in the experimental area were thinned out to two fifths of the original number at the end of 1963.

Table 5. Yield of made tea in quintals per hectare from 1964 to 1969 under sun, screen and shade trees as mean of the three manurial treatments. Yield of the highest yielding clone S 1D 3/5 and average of the 25 clones are shown separately.

	Shade tree		Screen		Sun	
Year	Average of 25 clones (q/ha)	Clone S 1D 3/5 (q/ha)	Average of 25 clones (q/ha)	Clone S 1D 3/5 (q/ha)	Average of 25 clones (q/ha)	Clone S 1D 3/5 (q/ha)
1964	15.9	28.8	13.4	19.1	11.5	23.2
1965	17.7	29.2	13.9	21.0	14.9	26.0
1966	19.6	32.0	14.6	21.5	18.0	28.2
1967	24.9	38.9	18.7	26.1	21.5	36.5
1968	33.8	50.2	25.3	33.7	29.1	40.8
1969	26.3	34.7	20.6	24.7	23.0	27.2
Average =	23.0	35.6	17.8	24.1	19.7	30.3

The average yields of the 25 clones and of the highest yielding clone S 1D 3/5 are shown separately in the table to give an idea of the maximum yield potential on this replanted site. It may be noted in this connection that majority of these 25 clones were below average in vigour and four of them from the Lushai *jat* were so delicate that it was a problem to get them established. Even the most vigorous of the lot, clone S 1D 3/5, yielded less than clone 19/29/13 (TV 1) used in the guard rows of the experimental plots. Hence, the 25 clones taken together can, at best, be regarded as equivalent to an average *jat* of tea. Secondly, the soil of the experimental area was of sandy loam type and well drained but being on a replanted site, was poor in plant nutrients and organic matter. The nitrogen level of the soil immediately before planting of the trial ranged from 0.07 to 0.09 per cent on dry weight basis.

There was a steady linear increase in yield from 1964 to 1967. The sharp rise in yield in 1968 could be attributed to the bushes being left unpruned in that year and the steep fall in 1969 to their pruning after an unpruned year. The maximum yield was produced by the plots under tree shade and the minimum by those under screens, the sun plots occupying an intermediate position. However, the screen plots out-yielded the sun plots until 1964, when most of the clones did not cover the ground, but no sooner a clone covered the allocated ground area, its yield under the screens decreased. Yield of clone S 1D 3/5 for 1964 illustrates the point. This is a clear demonstration that shade, mechanical or natural, is beneficial to young plants until they attain full ground coverage.

The clone S 1D 3/5 under tree shade registered an yield of 38.9 quintals/ha in 1967 under an annual prune when the yield was still rising and 50.2 q/ha in the following unpruned year. The corresponding yield averages for the 25 clones were 26.3 and 33.8 quintals per hectare.

With regard to leaf temperature on hot, sunny days and conservation of soil moisture during the dry, winter months, the growing conditions were more favourable under the screens, but yield-wise the performance of the bushes was much better under the trees. Even the sun plots gave higher yields than those under the screens. These results indicate that any benefit accruing from reduction of leaf temperature and conservation of soil moisture under the screens was offset by a large decrease in light intensity, after the bushes had covered the ground. On the other hand, the detrimental effect of reduced illumination intensity under the trees must have been more than compensated by some

factors in the shade trees which were highly beneficial to the yield of the tea bushes. Data on Table 6 will show that not only yield, but total weight of the bushes also increased under the trees.

Table 6 is based only on the third repeat of the trial from which the bushes were uprooted in early 1972 for measuring frame and root growth. The results are expressed as fresh weight per bush. Because of high correlation between fresh and dry weights of the different plant parts *viz.* root, frame prunings and pluckings, which in no case fell below r= 0.85 comparison between treatments will not be affected by conversion to dry weights. Conversion to dry weight is, however, being done to determine the absolute dry matter production under different conditions.

Table 6. Weight of growth removed as pluckings and prunings during the period 1961 to 1969 and weight of frame and roots determined by uprooting the bushes in early 1972. Data based on the average of 25 clones and expressed as grams fresh weight per bush for the different treatments in the third repeat of the trial.

		Shade tree			Screen			Sun		
		Treatments			Treatments			Treatments		
		1	2	3	1	2	3	1	2	3
(1)	Plucking	3924	4801	4412	3053	2788	3354	2977	2619	2896
(2)	Prunings	5463	6638	6004	4265	3996	4463	4752	4121	4109
(3)	Total of (1) and (2)	9387	11439	10416	7318	6784	7817	7729	6740	7005
(4)	Frame	1693	1848	1730	1300	1242	1361	1500	1315	1362
(5)	Roots	937	1436	1127	1101	1113	1070	1512	1216	1232
(6)	Total of (4) and (5)	2630	3284	2857	2401	2355	2431	3012	2531	2594
(7)	Total weight of whole plant i.e. (3) and(6)	12017	14723	13273	9719	9139	10248	10741	9271	9599
(8)	Pluckings (1) / Prunings (2)	0.718	0.723	0.735	0.716	0.698	0.752	0.626	0.636	0.705
(9)	Top (1, 2 and 4) / Root (5)	11.82	9.25	10.78	7.83	7.21	8.58	6.10	6.62	6.79

For description of treatments, see Table 4.

Treatment effects shown in Table 6 are averaged in Table 7 to display the gross effects of tree, screen and sun.

Table 7. Weight of pluckings and prunings for the years 1961 to 1969 and of frame and roots. Data based on the average of 25 clones and the three treatments under each of tree, screen and sun in the third repeat of the trial and expressed as grams fresh weight per bush. Figures in italics express the weight of different plant parts as percentages of the whole plant weight.

Plant part	Shade tree (g/bush)	Screen (g/bush)	Sun (g/bush)
Pluckings	4379	3065	2831
	32.8	*31.6*	*28.7*
Prunings	6035	4241	4327
	45.2	*43.7*	*43.8*
Frame	1757	1301	1392
	13.1	*13.4*	*14.1*
Roots	1167	1095	1320
	8.8	*11.3*	*13.3*
Total weight of whole plant	13338	9702	9870

It will be seen from Table 7 that the total weight of the whole plant was the maximum under tree shade and minimum under the screens. However, the highest root weight was produced in sun. Although in this (third) repeat of the trial the weight of plucked shoots in sun was less than that under the screens, the position was just the reverse when all the three repeats of the trial was taken together (cf. Table 5). The percentages given in italics show that the partition of growth between different plant parts was affected by the three light treatments. Tree shade increased the proportions of both pluckings and prunings, screens only of pluckings while sun increased the proportions of frame and roots. Thus, shading diverted a relatively larger fraction of the assimilates towards the production of plucked shoots, which is the economically useful fraction of growth.

The effects of the three nutritional treatments can be observed from Table 6. Nitrogen in combination with the other nutrients had almost no effect under tree shade, slight effect in sun and a little more effect under the screens. This is a surprising result for a replanted, well-drained site low in plant nutrients. The control plot under tree shade, which did not receive any nutrient all through the years, produced the highest yield in this (third) repeat of the trial, although in the other two repeats of the trial its yield was somewhat less than the plot receiving the nutrients (Tr. 3). This is another interesting result as a high level of yield (cf. Table) was maintained by the unmanured plot under the trees for long eleven years.

Removal of the shade tree droppings depressed yield by about 15 per cent and their addition to plots in sun and screens caused almost similar increase. Depending on the severity and time of lopping the trees to maintain light intensity at an uniform level in different years, the quantity of droppings varied from 2500 kg to 5000 kg per hectare per year, giving an analysis of 2.51% N, 0.88% K_2O, 0.71% P_2O_5, 1.27% CaO and 0.62% MgO. The total quantity of droppings and their contents of plant nutrients show that the droppings are of considerable nutritional value. However, even after removal of the droppings, the yield level of the plots in Treatment 1 under the shade trees was considerably higher than those of the manured plots in sun and screen. These results demonstrate that the benefits accruing from shade trees cannot be attributed solely to reduction of leaf temperature and turnover of nutrients. Further investigation is required to locate the sources of other benefits resulting from the trees.

Analysis of variance of the yield data of the experiment for different years has shown treatment, clone and clone × shade effects to be significant. In 1967, the factor of leaf pose was also introduced into the yield analysis. Leaf pose as a factor came out significant, but the interaction of leaf pose with shade failed to reach the level of significance. A consolidated analysis for the entire period of the experiment based on dry weight of plucked shoots is in progress.

Shoot count and spacing

The purpose of measuring the distribution of shoots on the plucking surface of a mature tea bush was briefly discussed in the Annual Report for 1968-69, pages 58-61. The results of this investigation were published in Two and A Bud (Vol. 18, No.1, pp. 8-11, June 1971; Vol. 20, No. 1, June 1973). It was deduced from these observations that the shoot count method could be used as a substitute for the time-consuming and expensive spacing experiments.

MITES

Distribution of Tea Mites : Survey on the distribution and abundance of scarlet, pink and purple mites on mature (25 year old) Assam jat of tea was continued under different agronomical and agroecological conditions. In general, all the three species of mites were more numerous on skiffed tea than on comparable pruned tea, except in Darjeeling where such clear cut response was not noticed this year, as against last year. Abundance of foliage on skiffed tea may be linked to the higher incidence of mites on them; apparently this was not true under Darjeeling conditions this season.

Comparable light pruned, light skiffed and deep skiffed teas under Cachar conditions did not differ significantly in their susceptibilities to purple mites. But scarlet and pink mite populations were least on light pruned tea compared to light and deep skiffed teas.

Assessments of seasonal mite populations on comparable jats (Silbhatta) and clones (TV 1; TV 2; TV 17; TV 18) indicated more pink mite infestations on clones than on jats, and more purple mites on jats than on the clones. Scarlet mites showed more preference for China jats than Assam jats. Since light distribution within the bushes regulates the mite distribution, clearly each species reacts to it differently.

The susceptibilities of ten Tocklai release clones to scarlet, pink and purple mites varied. TV 3 was highly susceptible to pink mite, as were TV 1 and TV 7 to scarlet mite.

Life system of red spider and scarlet mite : Weeds appear to be major links in the life system of red spider and scarlet mites. Weeds that are the major alternate hosts of red spiders in tea areas are listed in Table 1.

Presence of these weeds in tea areas initiates early build up of red spider populations because on all these weeds the mite completes its life cycle. The exact duration of the life cycle somewhat varies depending on the species of weed and time of the year. But in no case does the life cycle process on these weeds differ significantly from that on tea.

Table 1. Weed hosts of red spider in tea areas and the duration of red spider life cycle on them.

Weed species	Duration of life cycle in days in		
	March	June	December
1. *Litsaea polyantha* Juss	15—17	11—12	23—25
2. *Melastoma malabathricum* Linn.	15—17	11—13	24—26
3. *Borreria hispida* (L) K. Schum	11—13	11—14	24—26
4. *Scoparia dulcis* Linn.	17—19	—	24—26
5. *Melochia corchorifolia* Linn	—	11—12	—
6. *Jussiaea suffruticosa* Linn.	—	10—12	—
Tea	14—16	11—12	23—25

Alternate hosts of scarlet mite in tea areas are *Erechthites valerianaefolia* DC., *Pouzolzia indica* Gaud, *Clerodendron infortunatum* Gaertn, *Clerodendron viscosum* Vent., *Broussonetia papyrifera* Vent., *Litsaea polyantha* Juss, *Commelina benghalensis* Linn., *Melastoma malabathricum* Linn. Of these, *L. polyantha* and *M. malabathricum* are common to both red spider and scarlet mite. No significant difference is noticed in the duration of the life cycle of scarlet mite on two common weeds and on tea (Table 2).

Table 2. The duration of the life-cycle of scarlet mite on two species of weeds and tea.

Months	*Litsaea polyantha*		*Commelina benghalensis*		Tea	
	Minimum (Days)	Maximum (Days)	Minimum (Days)	Maximum (Days)	Minimum (Days)	Maximum (Days)
February	38	41	37	40	40	42
March	25	27	27	28	26	28
April	25	26	26	27	25	27
May	21	22	22	24	21	23
June	16	19	15	16	16	17
July	16	18	16	17	16	18
August	16	18	16	18	14	16
September	18	20	18	20	18	20
October	23	25	23	26	23	25

Scarlet mites have been recorded to infest *Albizzia lebbek* and *Albizzia odoratissima* in nursery and soon after planting out.

TEA APHID

Aphid Biology : On mature tea (over 15 years old) aphis (*Toxoptera aurantii* Boyer) population starts building up from mid-January. The peak is reached during March-April and with the formation of alates (winged forms) in May the population starts declining. The small second peak in August is formed as the alates start recolonizing the bushes.

Predators (Fig. 1) and parasites play a major role in the regulation of aphid population. The dominant predator last year was *Asarcina aegrota* Fab. (Syrphidae) and parasites were *Aphelinus* sp. (Aphelinidae) and *Trioxys* sp. (Braconidae).

Fig. 1. An aphid predator in a colony of aphids.

The predator *Asarcina aegrota* consumed, on an average, 120 aphids per day and this helped in the natural control of aphids. This predator is, however, highly susceptible to chemical pesticides.

Trioxys sp. is an internal parasite of the fourth instar and adult stage of the aphis: in a field count nearly 22% of aphis population was found parasitized. The parasite completes its life cycle within its host and the adult bursts out of the ventral surface of the insect.

Aphelinus sp. is also an internal parasite. The parasitised aphid becomes less mobile and changes its colour to metallic black. The degree of parasitization varies between 4% and 13%.

A round of spraying in late February or early March spared most of the natural enemies. The latter brought down the residual aphid population during April/May to such an extent that the second peak during August did not occur.

NEMATODES

Distribution of Nematodes : A survey was conducted in the Dooars to find out the relative abundance of different nematodes in tea soils supporting mature tea over 20 years. The frequency distribution of different nematode groups in the samples is shown in Fig. 2.

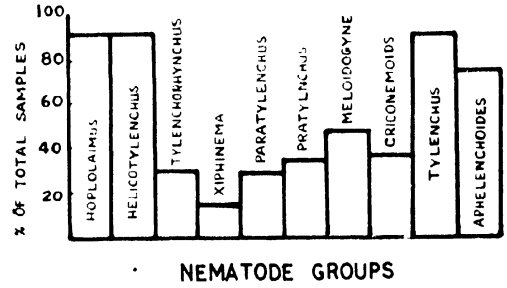


Fig. 2. Distribution of different groups of nematodes in tea soils.

Although all the groups isolated are not parasitic, *Meloidogyne*, *Pratylenchus* and *Paratylenchus* could be of consequence in tea growing. Their numbers in mature tea areas are comparatively less than in young tea areas.

Biology of Pratylenchus : *Pratylenchus brachyurus* Godfrey was found infesting the roots of two to three year old seedlings. Red lesion marks developed on the root zones where the nematode colonized. Egg laying females formed the bulk of the population. The life cycle of this nematode on excised tea roots is completed in about 30 days under laboratory conditions. The first instar developed within the egg whereas second, third and fourth instar larvae developed within the root tissues.

All the larval stages and adult feed on the sap of the root tissues. Consequently, the root growth is retarded and the nematode infested roots grow shorter than the non-infested roots. Above ground symptoms are gradual yellowing of the leaves and blackening of their edges; heavily infested plants become weak.

Pratylenchus loosi Loof was recorded for the first time from a few mature tea bushes. The infested plants suffered from severe debility leading to decline in vigour and growth. Its possible spread is being looked into.

Root knot Nematode distribution and alternate hosts : The abundance of the root knot nematodes (*Meloidogyne*) in tea nursery areas may be linked to the availability of weeds, wherefrom they move onto the roots of tea seedlings (Fig. 3) In

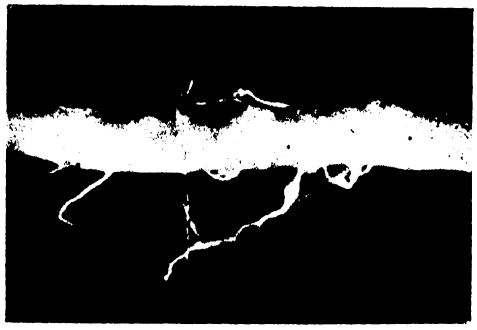


Fig. 3. Formation of galls on the root of a tea seedling by *Meloidogyne*.

weed free areas nematode numbers are significantly lesser than in comparable plots with weeds. The susceptibilities of some weeds and cover crops to root knot are shown in Table 3.

Table 3. Comparative index of *Meloidogyne* infestation on some weeds and cover crops.

Weeds	Infestation Index
1. *Colocasia antiquorum* Schott	1.75
2. *Oxalis acetosella* Linn.	2.30
3. *Scoparia dulcis* Linn.	1.75
4. *Amaranthus viridis* Linn.	2.00
5. *Mullogo stricta* Linn.	2.30
6. *Amaranthus gangeticus* Linn.	3.00
7. *Tephrosia vogelli* Hook	3.50
8. *Tephrosia candida* DC	2.00
9. *Solanum melongena* Linn.	4.00

Soil moisture level and root knot multiplication : To find out the importance of soil moisture level in the multiplication of root knots, equal numbers of *Meloidogyne incognita* were released in replicated pots containing soils varying in moisture levels i.e. 7, 15, 22 and 30% by weight. Nematode multiplication decreased proportionately with the increase in soil moisture. Except at 30%, none of these moisture levels influenced the pathogenicity of the nematodes.

Effect of nematicides on nematode multiplication : Populations of the root lesion nematode, *Pratylenchus brachyurus*, were reared in ten replicated pots (size 12 cm × 11 cm) holding 1 kg soil. Soils were treated differentially with Vapam at the rate of 0.2 cc and 0.4 cc per pot and Temik 10 at the rate of 0.1 g and 0.2 g per pot. The results are shown in Table 4.

Table 4. Effect of differential nematicidal treatment on the reproduction of *Pratylenchus brachyurus* in pots containing 1 kg of treated soil.

Treatment		Polulation per 100 g of soil			
Nematicide	Rate/kg soil	Before treatment	7 days after	20 days after	40 days after
Vapam	0.2 cc	420	0	40	80
Vapam	0.4 cc	400	0	0	0
Temik	0.1 g	680	0	20	20
Temik	0.2 g	520	0	0	0

Although the initial nematode population could not be maintained at the same level in different experiments, both nematicides gave excellent control. The population started building up from the 20th day onwards presumably from the eggs that survived the low concentrate application of nematicides.

PESTICIDES

Cockchafer trial : To find out the effect of various insecticides in repelling the grubs in combination with some management practices, Birlane, Thiodan, Thimet, Furadan and Dassanit were used in conjunction with management methods which included

1. Use of pits 45 cm deep and 45 cm wide: with soil loosened a further 15 cm at the bottom of the pit.
2. Firm ramming of the bheti or dhela during planting.
3. Use of one ounce of superphosphate mixed with the soil dug from planting pit.
4. Use of plants carrying 18 leaves and more.

Comparable series were run with only insecticidal treatments, and 'management methods' without any insecticidal treatment. A set of typical result is shown in Table 5.

Table 5. Integrated trials against Cockchafer grub.

Treatment	Percentage reduction in the number of cockchafer damaged plants
Any insecticidal treatment + management method ...	84.3
Treatment with any insecticide	
Birlane ...	73.4
Furadan ...	75.4
Thimet ...	73.7
Dassanit ...	77.2
Only management practice ...	56.1

In all cases the integrated approach i.e. management methods plus insecticidal treatment, gave a greater protection to the plants than chemical treatment or management methods alone; the latter gave the least control.

Trials against Scale insect : Trials against a common scale in Darjeeling, were conducted using Sumithion, Nuvacron, Zolone, Dursban, Delnav and PP 511, applying each separately at 1.25 litre to a hectare. Mortality counts after 4 weeks were as follows (Table 6).

Table 6. Effect of some insecticides on scale insect population after 4 weeks.

Insecticides	Average scale population in twigs of 15 cm	Percentage reduction over control
Sumithion	9.00	65.38
Nuvacron	3.50	86.53
Zolone	5.00	80.73
Dursban	3.25	87.50
Delnav	7.50	71.15
PP 511	2.50	90.38
Control	26.00	--

Mortality from PP 511, Dursban and Nuvacorn was higher than Delnav and Zolone : Sumithion gave the least control.

Looper caterpillar : Field trials against late instar looper caterpillars (*Biston suppressaria* Guen) were conducted using Bidrin, Thiodan, Dursban, Nuvacron, Zolone, Furadan and Hexafen. Each insecticide was sprayed separately at 1.25 litre to a hectare using a power sprayer. Mortality counts were taken on the second and seventh day after spraying to find out the immediate and residual effects of the pesticides respectively. The results summarised in Table 7 show only marginal difference in the immediate and residual effects of the insecticides.

Table 7. Number of looper caterpillars per twig of 25 cm length following insecticidal treatments.

Treatments	Population on second day		Population on seventh day	
	Mean	% reduction over control	Mean	% reduction over control
A. Thiodan @ 1.25 l/ha	9.50	89.00	1.25	96.12
B. Bidrin @ 1.25 l/ha	21.25	72.00	7.25	77.52
C. Dursban @ 1.25 l/ha	19.75	77.00	3.75	88.37
D. Nuvacron @ 1.25 l/ha	20.50	76.00	4.75	85.21
E. Zolone @ 1.25 l/ha	26.25	69.50	9.50	70.54
F. Furadan @ 1.25 kg/ha	31.50	63.40	5.75	82.17
G. Hexafen @ 1.25 l/ha	9.75	88.70	2.75	91.47
H. Control	86.00	--	32.25	--

Trials against red spider : The toxic effect of several new acaricides on red spider population at different density levels was studied. Spraying was done in April when the population started increasing and another in June when the population was at its peak. The average population per 50 leaves in April was 197 as against 996 in June. The results of the trials are shown in Table 8. Population counts were made four weeks after spraying. In both the experiments, irrespective of the initial mite population levels, the acaricides kept the mites under control for four weeks, though their individual performance varied

Table 8. Trials against red spider at two different seasons (Mean number of mites/50 leaves in 4th week after spraying).

Treatments	April	June
Imidan	62.67	—
Zolone	49.33	408.33
PP 511	43.33	—
Kilval	25.33	—
Lovozal	21.67	345.67
Acarthane	19.33	9.00
Ethion	19.33	—
Furadan	19.33	—
Delnav	17.67	68.00
Nuvacron	10.00	43.67
Acrex	—	209.00
Plictran	—	79.33
Control	197.00	996.00

Toxicological studies with scarlet mite : Toxicities of Nuvacron 40 E. C. and Ethion 50 E.C. to a laboratory population of scarlet mite were evaluated by topically applying 0.2, 0.1, 0.05, 0.025, 0.012, 0.006 and 0.003 per cent concentrations of their active ingredients. The population kill in probit scale was plotted against log concentrations of the chemical and from these the values for LD_{90} and LD_{50} were read off (Figs. 4 and 5): field application at these dilutions also significantly reduced mite population.

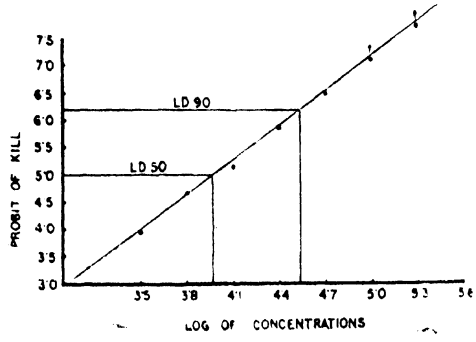


Fig. 4. Dosage mortality curve for Scarlet mite treated with Ethion.

Ambithion, Zolone, Phosvel and Lovozal were also tried against scarlet mite. All the acaricides caused significant mortality to the mite, though the actual toxic level somewhat varied with different acaricides.

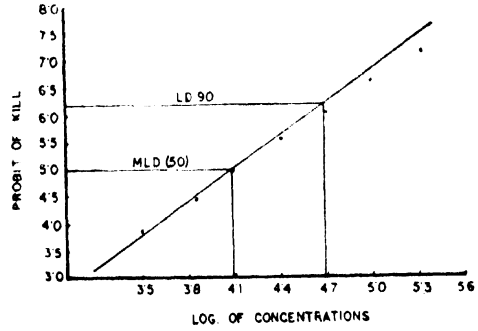


Fig. 5. Dosage mortality curve for Scarlet mite treated with Nuvacron.

Residue analysis : Tea leaf samples treated with Tetradifon and Dicofol were prepared for estimation of acaricidal residues. Both sundried and green leaf samples were prepared and these are now being analysed at the National Chemical Laboratory, Poona.

Taint analysis : Tea samples treated with Ambithion, Difolatan and DuTER were organoleptically tested for taint one week after the treatment. Tea tasters did not report any taint on teas treated with these chemicals.

Issuance of Certificate : 31 Certificates were issued to plant protection chemicals. Of these 20 certificates were revalidated after bioassay studies.

Mycology Department

Red rust

Red rust (*Cephaleuros parasiticus* Karst.) is the most prevalent disease of young tea, attacking the branches and causing extensive die back under favourable conditions. During the year, studies on the effect of soil compaction and long term manuring on disease incidence and chemical spraying on the disease control were made.

Soil compaction Vs Red rust

Soil compaction was observed to be concurrent with heavier red rust incidence in the field. Pot culture experiments to confirm the effect of soil compaction on the disease incidence has shown that the plants recorded a stunted growth in more compact soils (Plate 1). No disease has, however, yet appeared on any one of the plants in this experiment where both resistant and susceptible clones were grown.

Plate I. Showing tea plants growing in different compaction levels.

Long term manuring and red rust incidence

Observations were made in Borbhetta Area 5 for red rust incidence in 10 year old Tingamira receiving 4 levels of N (0, 45, 90, 135 kg/ha), 2 levels of P (0 and 22.5 kg/ha) and 2 levels of K (0 and 22.5 kg/ha) since 1965. The incidence of the disease was, however, found to be low in all the plots and it has therefore been decided to record the red rust infestation next year also.

Chemical control of red rust

Aerobiological studies as well as studies in the field on the sporulation and spore discharge pattern of red rust have indicated the necessity of increasing the number of spraying rounds. Efficient control of the disease has been achieved by spraying a standard copper formulation in 4 monthly rounds during the fruiting period of the alga (Ann. Rep. 1970-71). Usually 0.25% concentration of the chemical is sprayed with hand operated sprayers @ 3 kg per hectare per round. With power sprayers the concentration of the spray solution is increased and the spraying is done at the rate of 2.5 kg copper fungicide per hectare. It is encouraging to note that the gardens have realised the importance of giving more than 2 rounds and that the application of 4 rounds has been accepted as the norm. But in practice the time interval between the rounds generally varies from 2 to 4 weeks. It was, therefore, decided to compare the application of a standard copper formulation in 4 rounds at different time intervals. Tea grown virtually without shade in different estates and having severe infection of the disease was sprayed with Blitox, a copper oxychloride, at different intervals. In one experiment a power sprayer was used while in another experiment, a hand operated sprayer was used. The treatments were :

1. Control (unsprayed).
2. Blitox in 2 rounds at fortnightly interval (standard practice till late sixties).
3. Blitox in 4 rounds at fortnightly interval.
4. Blitox in 4 rounds, the first 2 at fortnightly and two subsequent ones at monthly interval.
5. Blitox in 4 rounds at monthly interval.

The same treatments were also applied to tea under heavy shade with hand sprayers only. Scoring of disease incidence was done on a scale of 0 to 4,

for all the bushes in each experimental plot of every replication. The average score of red rust incidence per bush is recorded in table 1 under each treatment.

Table 1. Incidence of red rust on a score of 0-4 as influenced by various treatments of spraying rounds under two shade conditions and types of sprayers.

Spraying rounds		Poor shade		Heavy shade
	Blitox used	Hand sprayer	Power sprayer	Hand sprayer
Control	—	2.64	2.56	1.51
2 fortnightly	5 kg/ha	1.40	1.41	0.90
4 fortnightly	10 kg/ha	0.97	0.94	0.36
2 fortnightly 2 monthly	10 kg/ha	0.52	0.49	0.34
4 monthly	10 kg/ha	0.51	0.53	0.30
C. D. at P.05		0.29	0.38	0.34
C. V.		13%	23%	37%
No. of bushes per plot		29	40	50

Though the red rust incidence is much heavier under poorly shaded conditions, the effect of different treatments is almost parallel. Furthermore, there is hardly any difference between the efficacy of hand and power sprayers.

The finding confirmed earlier conclusion that two rounds of copper fungicide sprayed at fortnightly intervals (old standard practice) significantly reduced red rust incidence. Increasing the spraying rounds to four, further reduced the disease incidence significantly.

Interestingly with four rounds, the interval of spraying had little influence on the control of red rust in heavily shaded areas. However, in poorly shaded teas four fortnightly sprayings were only half as effective as four monthly sprayings or two fortnightly plus two monthly sprayings : the latter two treatments being equal.

Metabolic changes and Red rust infection

Leaves from healthy plants and variegated and partially variegated leaves from red rust infested plants were analysed for amino acids and sugar contents by the Bio-chemistry Department. The results are given in table 2.

Table 2. Metabolic changes in tea leaves caused by red rust infestation.

Condition of leaves	% Amino acids in dry leaves	Sugar % in dry leaves
Totally variegated	1.912	3.90
Partially variegated	1.453	5.77
Un-affected	0.492	7.29
Young shoots	2.094	2.33

High amino acid content of the variegated leaves indicated hydrolysation of proteins, brought about by the infection. Low sugar content is suggestive of increased host respiration and absorption by the parasite. Use of this information for an improved control of red rust will have to await further developments in future.

Branch canker (*Aglaospora aculeata* Petch. Syn. *Tunstallia aculeata* (Petch) Agni:

Throny stem blight is a stem disease confined to the Darjeeling region, caused by a slow growing wound parasite that takes years to make its presence felt. Therefore, to assess the effects of treatments on the degree of development of the disease, it becomes necessary to keep an area under observation on a long term basis. This year observations were made in 3 different experimental sites to record the incidence of thorny stem blight in plots receiving (1) NPK, (2) High level of Potash and (3) a systemic fungicide.

NPK manuring and thorny stem blight

These observations have been continued since 1966, in an NPK experiment carried out by the Darjeeling Advisory Branch. The treatments included 65 kg N per hectare in combination with 0, 22 and 45 kg P_2O_5 and K_2O per hectare. No significant effect on the disease incidence was noticeable in any of the treatments.

High level potash and thorny stem blight

In this trial potash was applied at the rate of 0, 90, 180, 270 and 360 kg per hectare. It was found that a high dose of potash did not in any way influence the degree of disease incidence.

Systemic fungicide and thorny stem blight

An experiment was initiated during 1970 to study the effect of foliar application of a systemic fungicide (Benlate) in mitigating the disease incidence. Observation on the development of the disease till date has not shown any significant effect of the treatment.

Black rot (*Corticium theae* Bernard & *Corticium invisum* Petch)

Screening of fungicides : Hoe 6052 (Farbwerke Hoechst Ag.), Benlate (Du Pont de Nemours & Co.) and Dikar (Indofil Chemical Ltd.) were tried in the field to evaluate their efficacy in controlling Black rot. The products tested did not cause any significant reduction of the disease.

Chemical control of Black rot

In the Black rot control trial, laid out in the North Bank in the year 1968 (reported earlier), the application of 2 rounds of a standard copper fungicide (Blitox) at fortnightly interval during the crucial stage of development of the fungus resulted in a high reduction of the disease (80-92%) and greater yield return (8-10%). Application of 2 more rounds during the same period in 1969 resulted in a further reduction (91-96%) of the disease and higher yield return (14-19%) that year. The yield data have been collected by our North Bank Advisory set up and the observations on the progress of the diseases have been made by the Mycology Department over the years.

The figures for 1972 indicate a strong residual effect of the treatment. An increase of 15-18% in yield and 44-50% reduction in incidence of the disease is still being recorded in the sprayed plots (see Table 3). This is noteworthy considering the fact that the spraying was done in 1968 and 1969, just as the disease started showing up.

The figures reveal the beneficial effect of spraying against a disease that persists on a bush from year to year and reduces the maintenance leaf area, thereby affecting the photosynthetic potential of the plant. Interestingly spray of 2.5 kg/ha by Fontan sprayer is as effective as 4.5 kg/ha.

Table 3. Effect of chemical control on the incidence of Black rot on a score of 0-4, and yield of green leaf in 1972.

Treatments (given during 1968 and 1969)	Disease incidence		Yield of green leaf	
	average score per bush	as% of control	per plot of 40 bushes	increase over control
Blitox @ 4.5 kg/ha by Knapsack	0.77	56.3	44.8	17.0%
Blitox @ 2.5 kg/ha by Fontan	0.73	53.8	43.9	14.7%
Blitox @ 4.5 kg/ha by Fontan	0.68	50.1	45.0	17.6%
Control (unsprayed)	1.36	100.0	38.3	-
C.D. at P 05	0.37		2.6	
C. V. %	33.6		4.9	

High dose of potash and Black rot

Our observation till date have not indicated any consistent relationship, though in one trial we noticed a trend for more Black rot in high potash plots. Observations will be continued in this context.

Blister Blight

Blister blight in Assam was observed in April/May. 1971-72 was an abnormally bad year for blister blight in Assam.

An observation on the attack of blister blight on plots manured with high dose of potash did not indicate any relationship of the latter with disease incidence.

Purple root rot

Observation was continued in a garden in the North Bank to study the effect of chemical treatments on the development of purple root rot, a primary root disease of tea caused by *Helicobasidium compactum*. No mortality has since been recorded even in the control plots. The experiment is continued.

Charcoal stump rot

Four soil fumigants *viz.* Shell DD, Vapam, Telone and Dichloroethylene are being tried against charcoal stump rot, a primary root disease caused by *Ustulina zonata*.

Lightning

Two lightning affected patches were analysed for their microbial population by soil dilution method, on 5th and 16th day of the lightning strike, respectively. The results were very interesting. The fungal flora was not much affected by lightning but bacterial population diminished to only one fifth of that of the neighbouring soil.

In the past, the recommendation was to keep such patches under green crop for two years. In view of the above the replanting could be done in as little as 3-4 months. This can be done by uprooting all the woody materials to eliminate the setting in of primary root rots, followed by proper manuring with 150-200 tons of cattle manure and high levels of P & K. Further experiments are in progress.

Primary root diseases in slopes (Darjeeling)

In our observations on the prevalence of diseases in different localities it has come to our notice that the spread of primary root diseases can take place at a faster pace down the slopes if after uprooting of the dead plants, the infected material is allowed to remain on the soil surface, specially during the rains as these are naturally washed down and lodged in an otherwise disease free area to give rise to fresh foci of infection. It is, therefore, essential that while uprooting plants affected by primary root diseases, special care should be taken to remove all the diseased material from the site *in one operation* on the same day. Uprooting of such bushes are better avoided during the rains.

Biochemical Differentiation of Clones

Experiments were conducted to see whether differences in the cup-characters of teas detected by the Tea Tasters would reflect in simple biochemical attributes like enzyme activity and oxidisable polyphenols of green leaf (cf. annual report 1969-70).

The differentiation of 4 clones and 3 clones and a jat was reported in the annual reports of 1969-70 and 1971-72 respectively, on the basis of enzyme activity (QO_2, μl/ mg/ hour) and total oxygen uptake (μl/mg/2 hours) of green leaf and condensed polyphenols of tea *viz.*, theaflavins and thearubigins, the two principal groups of pigments or colouring factors responsible for the quality of North East Indian plains teas. However, even in the same source of leaf, a small variation in any of the stages (withering, rolling, fermentation and drying) of manufacture alters the contents of theaflavins and thearubigins of tea. Therefore, we cannot differentiate the closely related clones and jats on the basis of theaflavins and thearubigins alone. Keeping this view, enzyme activity (QO_2) and the total oxygen uptake of green leaf were determined for clones TV-2, TV-10 and TV-18 besides studying some other chemical constituents subsequently described. It was found that the increase of enzyme activity and total oxygen uptake of green leaf improved the quality of the corresponding black teas manufactured under identical conditions of processing. Thus on the basis of these findings, the biochemical ranking of the three clones may be placed in the order of clones TV-2, TV-10 and TV-18. London and Tocklai tasting panels also corroborated the biochemical ranking of clones.

In order to see whether other chemical components play any significant role in the above classification besides enzyme activity and total oxygen uptake, analyses of the chemical constituents *viz.*, chlorophylls (sum of a and b chlorophylls), amino acids (sum of aspartic acid, glutamic acid, serine, glutamine, alanine, tyrosine, valine and theanine), sugars (soluble), caffeine, soluble solids and total polyphenols (sum of (-)- epigallocatechin, (-)- epigallocatechin gallate, (-) epicatechin gallate and theogallin) of green leaf, residual polyphenols, theaflavins & thearubigins and caffeine of the corresponding teas were undertaken during the season.

Sugars and total polyphenols of green leaf were positively correlated with quality whereas amino acids and chlorophyll contents of green leaf were negatively correlated. Polyphenols were almost same in clones TV-2 and TV-10 but they were much lower in TV-18 (Figure 1). Amino acids were the highest in TV-18 and almost similar amounts in TV-2 and TV-10 throughout the entire season from April to end of November (Figure 2). Similarly sugars were the lowest in TV-18 but were almost similar in amount in TV-2 and TV-10. Caffeine was found to be the lowest in TV-10 inspite of high amounts of polyphenols and high enzyme activity. This is perhaps one of the reasons why clone TV-10 was inferior to TV-2. Reverse was the case with TV-18. It had low polyphenols and enzyme activity but high caffeine content. On the basis of these analyses it was found that the quality of clone TV-10 was almost similar to clone TV-2, although in ranking the three clones TV-10 was intermediate in quality. The quality of TV-18 was the poorest. Such a method of ranking the clones may also be extended to some other Tocklai release clones which were earlier analysed (Table 1).

Table 1. Biochemical order of preference of Tocklai release clones and jats on the basis of enzyme activity and total oxygen uptake of green leaf.

Clones & Jat	Enzyme activity (QO_2 *ul*/mg/ hour) (average 26 repeats)	Total oxygen uptake (*ul*/mg/2 hours) (average 26 repeats)	Biochemical order of preference
	QO_2 ± error	T.U. ± error	
TV-1	19.78 ± 0.11	12.09 ± 0.09	1
TV-2	19.47 ± 0.11	10.78 ± 0.08	2
TV-3	16.09 ± 0.10	10.70 ± 0.06	3
TV-14	16.94 ± 0.13	9.90 ± 0.03	4
TV-10	16.37 ± 0.093	8.80 ± 0.027	5
TV-12	17.40 ± 0.10	8.18 ± 0.09	6
TV-11	16.69 ± 0.12	8.15 ± 0.029	7
TV-8	15.95 ± 0.12	9.37 ± 0.01	8
Stock-450	17.79 ± 0.11	7.59 ± 0.03	9
TV-18	15.81 ± 0.082	7.96 ± 0.031	10

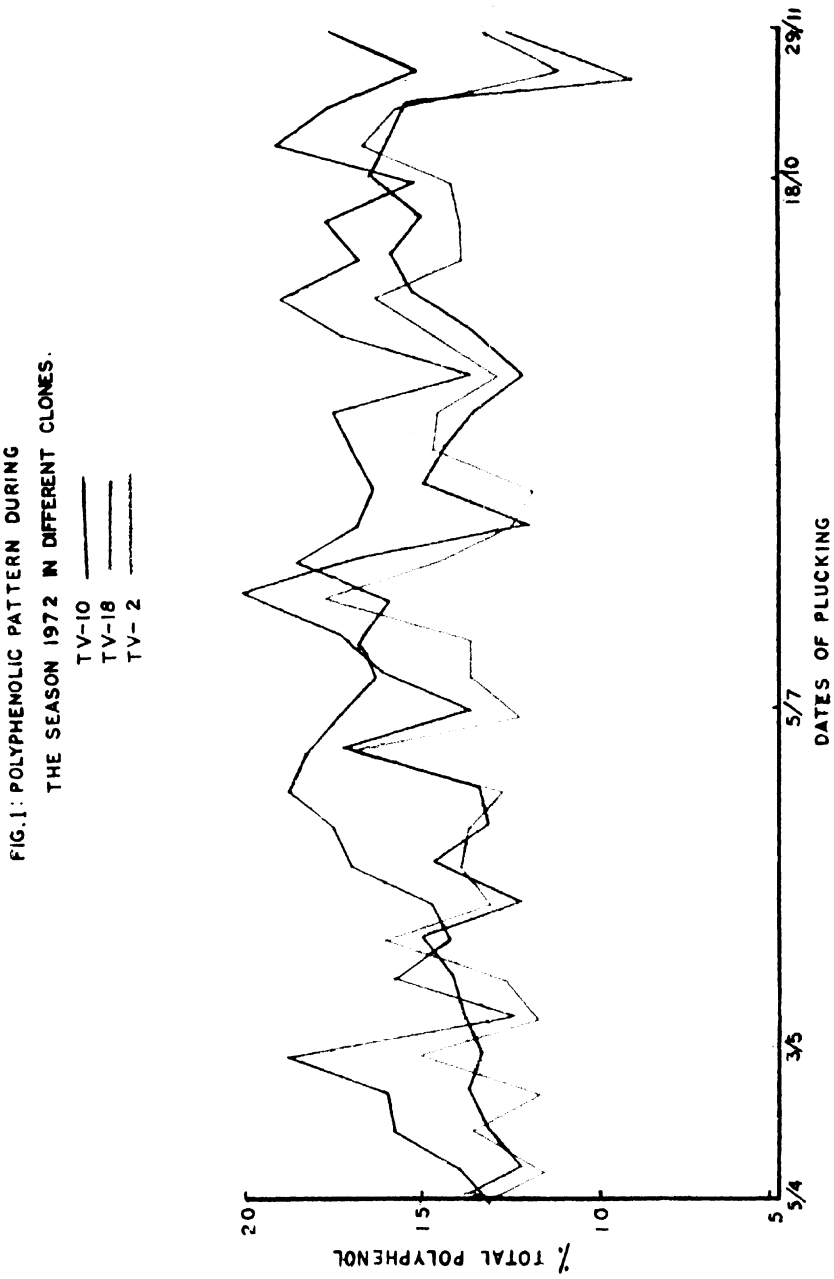
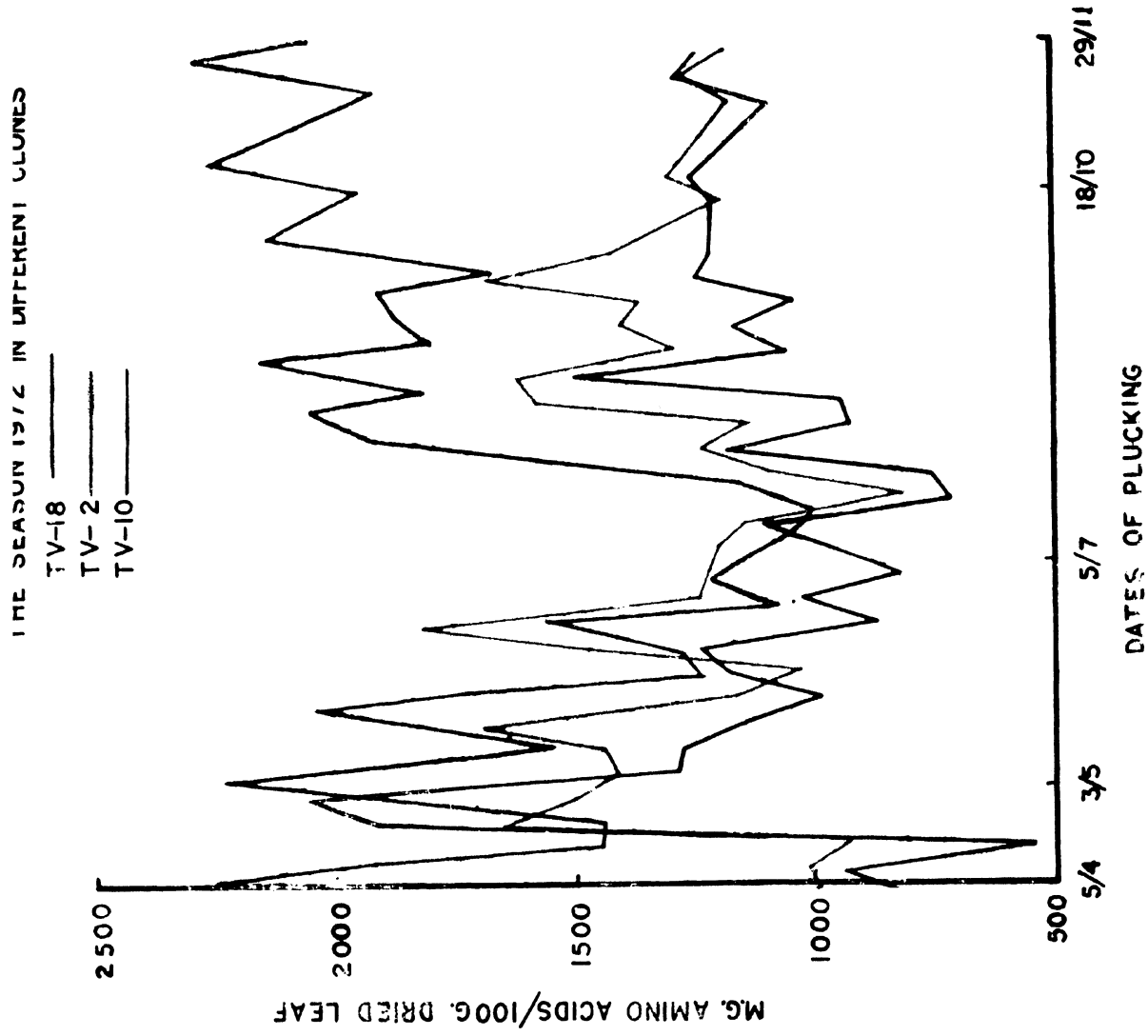


FIG.1: POLYPHENOLIC PATTERN DURING
THE SEASON 1972 IN DIFFERENT CLONES.
TV-10
TV-18
TV- 2
% TOTAL POLYPHENOL
20
15
10
5
5/4
3/5
5/7
18/10
29/11
DATES OF PLUCKING


THE SEASON 1972 IN DIFFERENT CLONES
TV-18
TV- 2
TV-10
MG. AMINO ACIDS/100G. DRIED LEAF
2500
2000
1500
1000
500
5/4
3/5
5/7
18/10
29/11
DATES OF PLUCKING

It was found that the enzyme activity (QO_2) of TV-14 was slightly higher than that of TV-3 but the total oxygen uptake of the former was appreciably lower than the total oxygen uptake of the latter. Although such differences between clones in enzyme activity and total oxygen uptake is real, this small difference does not reflect appreciably on the quality and therefore the clones TV-14 and TV-3 may be placed in the same rank. It was further observed that the clones TV-10, TV-11 and TV-12 were almost similar in nature owing to their similar enzyme activity and total oxygen uptake. As regards Stock 450, its enzyme activity was higher than that of clone TV-8 but the polyphenolic content of stock 450 was low. That is why stock 450 was ranked next to TV-8. The clone TV-18, however, was the poorest clone of all Tocklai release clones so far analysed.

Biosynthesis of polyphenols

The biochemical classification of the above clones indicates that quality increases with the increase of both oxidisable polyphenols and enzyme activity.

Recent *in virtro* studies of the metabolic pathway of polyphenols indicated that poor clones and jats having low polyphenolic content may possibly be improved by chemical means.

Tea shoots of two clones were dipped in water with and without chemical for 44 hours. Shoots were then dried in the usual manner and their polyphenolic contents were determined spectrophotometrically after separating them by two-way paper chromatography.

The results are given in table 2.

Table 2. Effect of chemical treatment on polyphenol contents of tea shoots.

	Experimental Clone 14/1-1		TV—1	
Treatment / Polyphenols	Water	Chemical	Water	Chemical
Theogallin	0.564	0.608	0.510	0.601
(-)-Epigallocatechin	3.017	3.587	5.191	5.592
(-)-Epigallocatechin gallate	2.663	3.558	4.561	5.039
(-)-Epicatechin gallate	1.264	1.371	2.225	2.231
Total	7.508	9.124	12.487	13.463%

The polyphenols, (-)- epigallocatechin, specially (-)-epigallocatechin gallate, increased to a great extent. These are responsible for the production of theaflavins, the golden yellow colour of a cup-infusion. However, (-)- epicatechin gallate, responsible for strength, did not increase appreciably.

Effect of pH on quality of tea

Attempts were made to regulate the formation of theaflavins and thearubigins and keeping qualities of made teas by adjusting the pH value of tea leaf during the processes of manufacture by suitable means so that a desired overall quality of tea could be obtained. A few commercial experiments were carried out in different tea estates during this season where 20 chests each of 6 grades were shipped. The tasting reports (London) of those teas clearly indicated that the quality of tea so manufactured was superior to normal ones. On an average there was a rise of about 25 per cent in rating or valuation. Market value of the treated teas was also higher.

Besides the rise in valuation, the other implication is that often the fermented leaf in commercial gardens cannot be dried in time due to sudden power failure and the quality of the tea so dried deteriorates. Such deterioration can be checked by adjustment of pH.

Further experiments will be conducted this year for application of this technique in the field.

Theaflavins from tea-waste for the improvement of poor quality tea

Theaflavins were extracted from tea waste and C.T.C. tea particles after fixing the thearubigins in the solution by alkaline buffer. The theaflavins so extracted were sprayed in different concentrations in water to the fermented tea leaf particles before drying to improve the quality of poor teas. Such teas on evaluation were found to show improvement in overall quality.

Study of spectra for theaflavins of underfermented, normal fermented and overfermented CTC teas

Theaflavins were extracted from underfermented, normal fermented and overfermented C.T.C. teas after fixing the higher polymer (Thearubigins) by

alkaline buffer in solution. The theaflavins so obtained were purified by precipitation from pure, dried chloroform (E. Merck). The spectra of the purified theaflavins and of the corresponding tea infusions were under study.

Miscellaneous Experiments

(a) **Analysis of red rust infested tea leaves**

Red rust infested dried green leaves collected by our Mycologist were analysed for amino acids and sugars. The results are presented in the report of Mycology Department.

(b) **Analysis of samples**

One hundred seventy-four tea samples from Iran, kenya. Botany Department, Research Engineering Department, Tea Tasting Department and various tea estates were analysed during the year.

(c) **Moisture Meters**

Nine infra-red moisture meters (Kaybee & N-Foss types) from various tea estates were calibrated during the year.

Tea Tasting Department

Quality vis-a-vis pruning & skiffing

The experiment on assessment of the cup character of the teas made from different modes of pruning and skiffing was also continued during the year.

In conformity with the earlier results (Ann. Rep. 1969-70, 71-72) the teas made from pruned bushes were found to be distinctly superior to skiffed and unpruned bushes.

Trough Vs. Natural wither

Object : To obtain 68% to 70% wither in 8 to 10 hours in trough with a hygrometric difference of 8°F and 10°F between the wet and dry bulb thermometers for comparison with natural wither.

For both trough and natural wither the wither obtained averaged to 70% and the withered leaf had an average moisture content of 68.4%. It was found that the best result was obtained with a hygrometric difference of 8°F. The liquors of the teas were superior in quality compared to natural wither. The teas produced with a hygrometric difference of 10°F were also satisfactory compared to natural wither.

Thickness of spread and fermenting times

Object : To determine optimum fermenting time and thickness of spread in the fermenting room for C.T.C. and orthodox types of manufacture.

C.T.C.

After the leaf was processed by the green leaf processing machine the processed leaf was spread immediately on trays in the fermenting room at thicknesses of between 13 mm ($\frac{1}{2}$") and 25 mm (1") for fermentation.

On every occasion teas fermented for 1 hr. 40 mins. with 13 mm ($\frac{1}{2}$") thickness was preferred followed by 1 hr. 30 mins. being fuller brighter and brisker in cup. The temperature in the fermenting room was 26°C–27°C (79°F-81°F) having a hygrometric difference of 2°F. It was also observed that leaf fermented for 1 hr. 50 mins. produced liquors which was comparatively dull and heavy on the palate.

Orthodox

The processed leaf was immediately spread on the fermenting room trays between 19 mm ($\frac{3}{4}$") and 38 mm ($1\frac{1}{2}$") thickness. The fermentation times taken for comparison were 2 hrs. 30 mins., 2 hrs. 45 mins. and 3 hours. The temperature in the fermenting room was 27°C (80°F) and the hygrometric difference maintained there was between 1.5°F-2°F.

On every occasion processed leaf fermented for 3 hrs. with 19 mm ($\frac{3}{4}$") thickness was preferred followed by 25 mm (1") thickness. The liquors of the teas fermented for 2 hr. 45 mins. achieved aroma, strength, brightness and briskness. The teas fermented for 2 hrs. 30 mins. had only a little colour and strength with a slight greenish taste.

Dual Manufacture

The effect of dual manufacture with Tocklai released clones *viz.*, TV1, TV2, TV4, TV6, TV12, TV16, TV17, TV18, and Stock 450 was under experimentation. Work carried out so far has not yielded sufficient information but from the preliminary findings it seemed that TV1, TV2, TV4, TV 6, TV9, TV16 and TV17 may be suitable for orthodox with scope for TV8, TV9, TV18 and Stock 450 for C.T.C. in dual manufacture.

It is proposed to continue the experiment further.

Blending and Fermenting

Experiments on blending of clones and standardisation of fermenting time for individual Tocklai released clones were carried out. Initial results were interesting and the experiment is being continued.

Long term trial of clones

During the year 1972 leaf samples of 13 clones from a long term clonal selection trial each weighing one kilogram were manufactured in the Miniature Factory both by Orthodox and C.T.C. methods

for evaluation of their cup characters. These teas were tasted 18 times at Tocklai, 10 times at Calcutta and 12 times in London by the respective Panels of Tasters. From this experiment three clones appeared to be of promising quality.

In regard to this experiment another lot of 11 clones from Indo-China and China hybrid stocks were manufactured and tasted by Tocklai, Calcutta and London Panels of Tasters. The results showed 2 to 3 clones to be promising in cup characters.

Selection of flavoury clones

Five Chinary clones together with two controls were manufactured in 1 kg rollers by orthodox and C. T. C. methods for assessing cup characters. These teas were tasted on 22 occasions at Tocklai, 11 occasions in Calcutta and 13 occasions by London Panels of Tasters. Two clones appeared to be promising with good flavoury character and acceptable liquors.

Biclonal progeny

During the year 10 samples of experimental biclonal stocks were manufactured by orthodox and C. T. C. methods for evaluating the cup characters. Tasting results indicate all the stocks to be more or less similar in their cup characters.

Eight samples of Rydak biclonal stock together with one control were manufactured in the Miniature Factory by orthodox and C. T. C. methods for evaluation of their liquors. None of the biclonal stocks were found to be of outstanding quality.

Grafting experiment

In continuation of the experiment on grafting (Ann. Rep. 1971-72) nine samples were manufactured in the Miniature Factory during the year by the C. T. C. method to see the influence of root stock on quality of grafted scions. In conformity with the earlier result, this year's result also showed that the root stock could have slight influence on quality of leaf of the grafted scions, but the difference was not marked.

Flush characters : Differentiations of Tocklai released clones

93 samples of TV2, TV10 and TV18 were manufactured in the Miniature Factory by C. T. C. method on weekly intervals commencing from April (1st flush) to the end of November. These teas were tasted by Tocklai, Calcutta and London Panels of Tasters and it was found that of the three clones selected for this trial TV2 was the best followed by TV10 and TV18 in cup quality throughout the season.

TESTING OF COMMERCIAL PRODUCTS

Non-Interleaved tea chests linings

This lining was supplied by Messrs Williamson Magor & Co. Ltd., to find out its suitability or otherwise for packaging of tea. The experiments are in progress.

Jute lac boards for tea chests

Sample of this product was supplied by Indian Jute Industries Research Association, Calcutta. The tea chests made of jute lac boards bulged even with a storage period of three months time and appeared to be weaker than the normal tea chests. But no taint was detected in the liquors of teas packed in jute lac boards.

Teas stored in jute lac boards chests also picked up more moisture as compared to normal chests. The material was therefore considered unsuitable for use as tea chests.

Deepclean (liquid detergent)

This product sent by Messrs D. M. Industries (India) Calcutta is being tried to find out its suitability as a cleaning agent in tea factories. Result of the trial will be available in the next manufacturing season.

Pervenol - N (detergent & cleaning agent)

This product sent by Messrs Industrial Sales & Agencies, Calcutta is being tried to find out its suitability as a cleaning agent in tea factories. Result of the trial will be available in the next manufacturing season.

'Reliance' Brand Hygienic Food Conveyor Belting

Sample of conveyor belting received from Messrs Halder Agencies Ltd., Calcutta was tried and the

product was found suitable for use as a conveyor for green leaf processing machines. The material did not impart any taint to the made teas provided it was thoroughly washed to remove the cleaning agent with clean water.

Aluminium linings

Some random samples of aluminium linings of ·025 mm and ·020 mm gauge used by commercial estates were collected for packaging of tea in plywood tea chests. The object of the experiment was to have an impervious layer in tea chests to stop moisture absorption from atmosphere and also to find out how it compared with the experiment carried out with some aluminium linings collected in 1968-69.

Observation made on these aluminium linings revealed that linings of ·020 mm gauge were appreciably less porous compared to a preliminary investigation made with linings in 1968-69 season (Ann. Rep. 1968-69, p. 89). However the random samples were considered to be suitable for using as linings for bulk packaging.

TEA TASTING AND ESTATE VISITS

Tea Tasting : During the season 3,554 experimental samples from Tocklai, 7,132 samples from estates for advising on manfacture and 4,079 clonal samples from estates were tasted. Besides this, a large number of samples were also tasted during the visits to the factories.

Estate visits and tasting sessions : The Tea Taster visited 32 factories for advising on manufacture and attended 25 tasting sessions.

Engineering Research & Development Department

RESEARCH & EXPERIMENT

ROLLING

Continuous Green Leaf Processing Machines

1. **Disc Type Continuous Roller :** Work on perfection of the commercial prototype 122 cm (48") Disc Roller and the finalisation of the battens was continued during the year. Different sets of battens were tried out at the pilot factory upto the end of June and the comparative samples of teas manufactured by the Disc Roller and Conventional Roller were tasted by Tocklai and London panel of Tasters. A summary of tasters report is given below :

Date of manufacture	Tocklai Tasters (Rs/kg)		London Tasters (Marks)	
	Disc Roller	Conventional Roller	Disc Roller	Conventional Roller
16.5.72	6.04	6.97	4.96	6.08
23.5.72	5.99	6.71	3.78	4.89
26.5.72	6.13	7.00	3.82	4.30
30.5.72	5.19	6.16	3.06	3.79
6.6.72	3.19	6.04	3.97	4.04
7.6.72	5.16	6.11		

On make and appearance, both Tocklai and London Tasters remarked in most of the cases that the teas are fairly twisted and contain some silvery tips.

The Disc Roller at this stage was shifted to and installed at Heeleakah factory and was tried out there against the factory's conventional rollers. Tocklai Tasters valuations of the comparative samples collected from these trials are given in the table below :

Valuations Rs./kg

Date of manufacture	Disc Roller				Conventional Roller			
	1st fine	2nd fine	3rd fine	Coarse	1st fine	2nd fine	3rd fine	Coarse
12.7.72	6.50	5.00		5.00	6.50	6.00		3.90
13.7.72	5.00	4.00	5.50	6.00	6.00	6.00	5.00	7.00
14.7.72	6.00	6.00	6.00	6.00	6.50	6.50	6.50	6.50
15.7.72	6.00	6.00	6.00	6.00	6.50	6.50	6.50	6.50
18.7.72	6.00	6.00	5.50	5.50	7.00	7.00	6.50	6.50
19.7.72	6.00	6.00	6.00	5.50	6.50	6.50	7.00	6.50
20.7.72	3.60	3.60	3.00	3.00	6.00	6.00	6.00	5.50
25.7.72	6.00	6.60	6.10	5.50	6.50	6.50	6.00	6.00
26.7.72	5.00	5.00	4.00	3.00	6.00	6.00	6.50	5.50
8.10.72	6.00	7.00	6.55	6.00	6.00	6.50	6.60	6.60
27.10.72	6.00	6.60	7.00	7.00	6.50	6.50	6.00	6.00
29.10.72	5.10	5.50	4.00	3.00	6.60	6.50	6.10	6.10
3.10.72	1st Roll	6.50	6.50	6.50	—	7.00	7.00	6.00
27.10.72	in	6.00	6.50	6.00	—	6.10	6.00	6.10
29.11.72	Conventional Roller	6.60	6.60	6.10	—	6.10	6.10	6.00

On dry leaf appearance Tocklai Tasters have remarked that the Disc Roller leaf is blackish with some silvery tips and a few stalks and unprocessed green leaf. The fines are reported to be fairly well twisted particularly when the Disc Roller was used after the 1st roll in a conventional roller.

It appears that the processing action on the fines obtainable with the Disc Roller is comparable to that of the conventional rollers, particularly on the samples obtained from the tests where the Disc Roller was used for the second and third roll. But the Disc Roller will require further improvement in respect of the make of the whole leaf grades if the machine has to be used on its own. The Dise used in conjunction with the conventional roller produces the necessary leaf style and improves the liquors of the 2nd, 3rd fines and coarse mal. Work in connection with its improvement is in progress.

2. **Barbora Continuous Leaf Conditioner :** There is nothing to report on this machine apart from the fact that a further batch of four machines were manufactured by Port Engineering Works and sent to an Upper Assam Estate, one Dooars Estate and a South Indian Estate.

3. **Leaf Sizer Attachment :** The Leaf Sizer Attachment was tried out successfully with a 15" rotorvane at Kakajan factory only for a few times towards the beginning of the season after which it had to be stopped there because of inadequate power supply. The attachment was then shifted to Cinnamara factory and similar trials were carried out there with a rotorvane against the normal rotorvane/C. T. C. manufacture. Tocklai Tasters' valuations of the comparative samples collected from these trials are given in the table below :

Valuations in Rs/kg

Date of manufacture	Rotorvane + Cutter (1 cut)	Rotorvane + C.T.C (2 cuts)
5. 8. 72	6.60	6.00
8. 8. 72	5.00	6.00
10. 8. 72	6.00	5.50
11. 8. 72	5.10	6.60
12. 8. 72	4.00	5.50
17. 8. 72	6.00	7.00
23. 8. 72	6.00	6.10
31. 8. 72	5.00	5.10
13. 9. 72	7.00	6.00
27. 9. 72	6.50	7.00
28. 9. 72	6.50	7.00
4.10. 72	7.00	6.50
28.10. 72	5.10	6.00
1.11. 72	5.50	6.00
2.11. 72	6.00 (followed by 1 C. T. C. cut)	5.50
14. 11. 72	5.10	6.00

Towards the end of the season the Cutter Attachment was taken to Meenglas factory in Dooars for trials under Dooars conditions. The following table gives Tocklai Tasters' valuations of the comparative samples collected from these trials at Meenglas factory :

Date of manufacture	Rotorvane + cutter (1 cut)	Rotorvane + Cutter (1 cut) + CTC (1 cut)	Rotorvane + cutter (1 cut) + CTC (2 cuts)	Rotorvane + C.T.C. (2 cuts)
29.11.72	-	5.10	-	5.50
30.11.72	5.00	3.90	4.00	5.10
1.12.72	-	5.00	5.10	4.10
2.12.72	4.10	5.00	5.00	5.00

According to Tocklai Tasters in all the above cases leaf is well cut, but contains some fibre.

The cutter attachment was intended to be developed to work in conjunction with continuous leaf conditioners. However, as 15" commercial B. L. C.s were not available near Tocklai, the attachment was modified to suit 15" commercial rotorvanes. From the limited number of trials with commercial rotorvanes it appears that at this stage of development even in conjunction with the rotorvane this cutter attachment can easily replace the first cut in C. T. C. and the leaf emerging from this attachment will require one subsequent C. T. C. cut to make them marketable at par with normal rotorvane with two C. T. C. cuts.

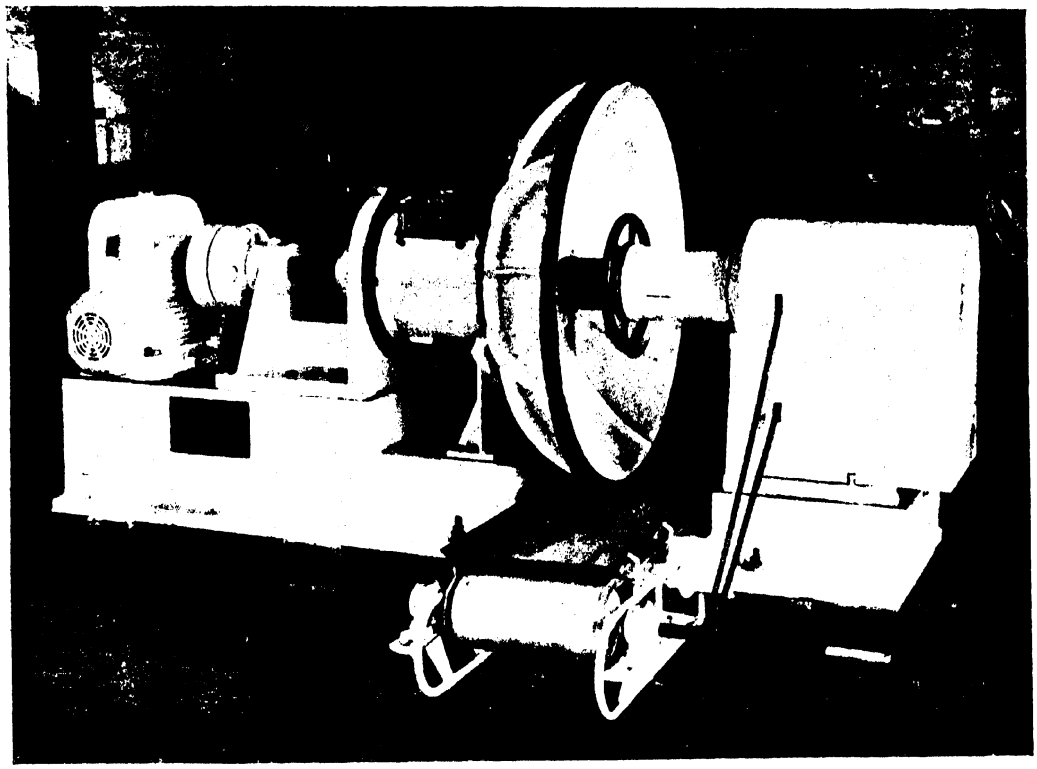
Fermentation

Tocklai Continuous Fermenting Machine : The first commercial unit of the Tocklai Continuous Fermenting Machine has been manufactured by S. F. India Ltd. and was installed at Ethelwold T. E. near Dibrugarh. In this machine the trays have been eliminated and better air washing arrangements have been introduced.

Drying

Tocklai Continuous Tray Tea Drier : The first Mark II version of this drier made by Steelsworth was installed at Bogapani T. E. The capacity

of this drier is reported to be around 220 kg of C.T.C. tea per hour under favourable conditions. The construction of the second drier by them is progressing. The other licensees, Wesman Engineering Co. have also completed the construction of their first drier.



48" Prototype Commercial Disc Roller.

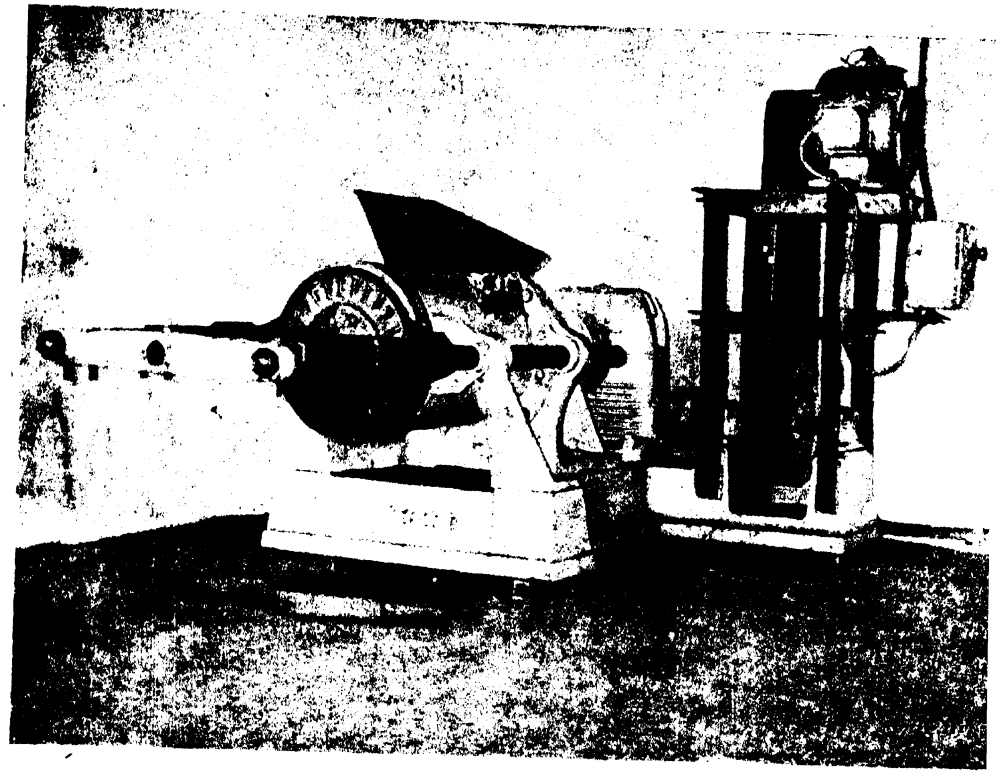
Miscellaneous

Tikmany Tea Sorting Unit : The Tikmany Tea Sorting Unit was tried out on eight different occassions to compare its performance with the normal sorting process at Duklingia Tea Factory. While the Tikmany Sorter gives five grades, Duklingia makes six grades. The Tikmany sorter grades may be named as (1) BOP, (2) BP, (3) OF, (4) PD + D and (5) CH.

The average percentage weights of the grades obtained in these comparative trials are:

Tikmany Sorter		Duklingia Process	
BOP	23.53%	BOP	10.48%
BP	5.97%	BP	14.09%
OF	19.75%	OF	32.21%
PD + D	40.19%	PD	18.42%
		D	9.35%
CH	5.38%	CH	1.05%
Spill	5.21%	Spill	14.39%

From this it is seen that the Tikmany Sorter gives higher percentage of BOP, PD + D and CH grades and lower percentage of BP and OF than the Duklingia normal process.



15" Barbora Leaf Conditioner with Prototype Cutter Attachment.

Samples of all the different grades from both the sorting processes were tasted and reported on by Tocklai Tea Tasters. The average valuations of salable teas on percentage weight basis calculated from Tocklai Tasters' valuations of the different grades are as follows:

Date	Average valuation Rs./kg		Amount of spill (Unsortable teas)	
	Tikmany Sorter	Duklingia process	Tikmany Sorter	Duklingia process
6.10.72	5.70	5.72	6.90%	11.17%
7.10.72	6.05	5.55	3.45%	11.17%
13.10.72	6.03	5.77	5.00%	11.17%
19.10.72	6.08	5.38	6.42%	16.25%
20.10.72	4.76	5.02	5.31%	16.25%
21.10.72	5.72	—	4.96%	16.25%
24.10.72	5.88		4.67%	16.25%
25.10.72	5.87	4.84	5.00%	16.68%

Average valuations :
Tikmany Sorter Rs. 5.75
Duklingia normal process Rs. 5.31
Difference Rs. 0.44 in favour of Tikmany Sorter.

From the Tocklai Tasters' reports, it appears that in most of the cases, teas sorted by Tikmany Sorting Unit contain some fibre and are comparatively larger in size. They are also reported to be mixed in a number of cases.

From the results obtained to date, it appears that Tikmany Sorter produces a higher percentage of primary grades and with a more efficient cleaning arrangement, the machine will prove to be very useful.

C. T. C. Dust : To study the particle size magnified photographs of C. T. C. dusts produced by C. T. C. rollers with different numbers of milling and chasing grooves were taken under microscope. A seperate article on this aspect will be published in due course.

General

The Senior Research Engineer visited the Central Fuel Research Institute from 11. 4. 72 to 13. 4. 72 and had useful discussions with the Scientists there on the problems relating to combustion of various types of fuels available to the Tea Industry in North East India and modernisation of heat exchangers and tea drying equipment. He has since reported to the Secretary, Tea Research Association on the possibility of taking up these projects in collaboration with them. He attended the Annual Scientific Conference of UPASI at Coonoor, two Engineering Sub-Committee meetings at Calcutta, two meetings of the Area Scientific Committees held at Panitola and Doom Dooma and the Joint Area Scientific Committee meeting at Dooars. He also attended the demonstrations of the Tocklai Continuous Tray Tea Driers made by Wesman Engineering Co. at Calcutta and Steelsworth Ltd. at Tinsukia. Further he visited the factory of Shaw Wallace & Co. in Madras to explore the possibility of manufacturing the Manual Plucking Aid there. He paid 36 advisory visits to different factories during the year.

The Second Research Engineer paid 12 advisory visits to different factories during the year.

Statistics Department

Crop-Weather Studies

Compilation of monthly crop and weather data collected through mailed questionnaire from Member estates in the Dooars for 16 years (1957-72) has been completed. The data are being checked and scrutinised for analysis on the electronic computer. Compilation of data collected from Member estates in Cachar is in progress. The object of this study is to find out the most critical periods and quantity of rain which affect the annual yield of tea in the Dooars and Cachar, and to predict the irrigation requirement (if any) for these localities. These results will be tested by actual field trials.

Sampling and Experimental Technique

The study to maximise the efficiency and minimise the cost of experimentation on the adjustment of post-treatment yields for individual years by the ancillary variables, namely, pretreatment yields upto June, July & August, September, October, September to end season, October to end season, November to end season, whole season's crop and the pretreatment pruning weights, continued during the year. Analysis of data from 23 long-term experiments ranging from 5 to 18 years in the Assam Valley, Cachar, Dooars and Darjeeling showed that pretreatment yields from September to end season was either more or almost equally efficient compared to other ancillary variables for adjusting the individual years' post-treatment yields in the plains of North-East India. In Darjeeling, however, pretreatment yield of July & August was found to be either more or almost equally efficient compared to other ancillary variables. Further, in general, the adjustment of post-treatment yields by the respective efficient pretreatment yields was found to be effective on the yield data of individual years upto about 10 years in the Assam Valley and Darjeeling, and 6 years in the Cachar and Dooars.

These results, therefore, suggest that instead of taking the whole season's crop as the ancillary variable, pretreatment yields from September to the end of the season in the plains of North-East India and July & August yields in Darjeeling will be sufficient to adjust the individual years' post-treatment yields. These results are similar to those obtained for cumulative totals of post-treatment annual yields (Ann. Rep., 1970-71, pp. 81-82) Application of these results will, therefore, not only minimise the cost, but also will increase the efficiency of experimentation in some cases.

Long-term Survey-Experiments on Defoliation

(a) **Current Season**

During 1971/72 cold weather, the two main plot treatments, Prune-Deep Skiff and Prune-Deep Skiff-Medium Skiff, were deep skiffed and medium skiffed, respectively. The data collected during the year 1972 from the experiments in the Dooars were analysed.

The red spider infestation was practically nil in all the experimental plots including the control (no defoliation and no chemical spraying) plots. Since red spider infestation was practically nil, no spraying was necessary in 34 out of the 36 chemical palliative plots. However, the yield of defoliated plots was found to be much lower than the undefoliated plots with or without chemical prophylactic spraying with tetraduphon (Tedion). The loss was found to be more than that of last year (23 p.c. as against 17 p.c. last year, averaged over two main plot treatments) over the undefoliated chemical prophylactic sprayed plots. As in previous years (Ann. Rep., 1968-69, pp. 102-106; 1969-70, p. 80; 1970-71, p. 82 and 1971-72, p. 77), this loss may be attributed to the detrimental effect of the continuous defoliation. No difference in yield between the chemical prophylactic sprayed plots and the control (no defoliation and no chemical spraying) plots was observed. This was understandable because the red spider infestation was practically nil.

(b) **Long-term Effects**

This field experiment was laid out in the Dooars in 1963. The details of layout and treatments were reported in the earlier report (Ann. Rep., 1968-69,

pp. 102-106). It was discontinued at the end of 1972 plucking season. The combined analysis of data over years collected from 1963 to 1972 is in progress to study the objectives outlined in the earlier report (Ann. Rep., 1968-69, pp. 102-106).

Some of the tentative results obtained so far from the preliminary combined analysis (1963-72) are given below :

Since the start of the actual treatments in 1964 until the 1972 season, red spider infestation was generally very low in all the experimental plots except in 1968 when all the control (no defoliation and no chemical spraying) plots except one were severely attacked by red spider. The peak period of infestation was found to be April and May, 1968, and the average percentage area of tea bushes affected in the control (no defoliation and no chemical spraying) plots was 35.7 p.c. However, in all the treated plots, red spider was controlled satisfactorily. The yields from these treated plots were higher than the badly attacked control plots which were neither defoliated nor sprayed with chemicals.

Although, defoliation or chemical prophylactic or chemical palliative spraying controlled red spider satisfactorily, the yield of the defoliated plots was found to be significantly lower from the fourth year onwards than the undefoliated plots which received only the chemical prophylactic spraying and the loss gradually increased with the years. This can be seen in Fig. 1, both for 2-year and 3-year pruning cycles.

It is interesting to note from Fig. 1 that the loss in yield due to continuous defoliation was generally more pronounced in the defoliated plots of 2-year pruning cycle than the 3-year pruning cycle. It is possible that this is caused by continuous defoliation having a greater detrimental effect on frequently pruned tea than on tea which is less frequently pruned.

Further, during 1968/69 and 1971/72 cold weather, when the 3-year pruning cycle plots received medium-skiff, no defoliation was carried out in the plots assigned for defoliation. It may be noticed from the figure that in spite of having no defoliation operation on these plots during 1969 and 1972, there were significant losses in yield in both the years and these losses were more compared to the corresponding losses in the previous years, i.e., 1968 and 1971 respectively when the specified plots were defoliated. This suggests that harmful effects of continuous defoliation for some years is carried over on the yielding capacity of tea bushes.

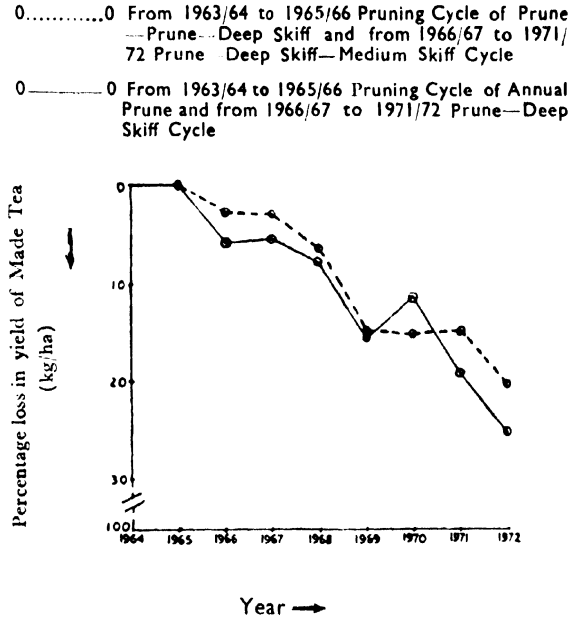


Fig. 1 : Percentage loss in yield of made tea (kg/ha) due to continuous defoliation over undefoliated chemical prophylactic sprayed plots from 1964 to 1972 for 3-year and 2-year Pruning Cycles.

Help to Other Departments

The Department continued to extend co-operation and help in solving statistical problems encountered by research workers of practically all the Departments of the Station. Analyses of a number of long-term experiments on the electronic computer at the Indian Institute of Technology, Kanpur continued during the year.

Statistical Study of the Chemistry of Tea

A scientific paper entitled 'Statistical evaluation of the important biochemical constituents and their

effects on colour, brightness and strength of North-East Indian plains black teas' was submitted to the 'Journal of the Science of Food and Agriculture' in U. K. and has been accepted for publication. The results of this study were reported in the last report (Ann. Rep., 1971-72, pp. 77-80).

Survey on Field Management and Environmental Factors Affecting the Yield of Tea in the Dooars and Terai, West Bengal

Compilation and checking of survey data on yield, fertilisers, type of planting, plant population, type of tea, age of tea, soil type, vacancy percentage and various other environmental and field management practices collected from the estates' records for 16 years and for each section in all the 112 member estates in the Dooars and Terai during 1967-69 has been completed. Scrutiny and coding of the data are in progress. This type of work does not lend itself to desk calculators and, therefore, the large mass of data is to be analysed on the electronic computer. Preliminary work on card designing, punching of the data on the card, verification, checking, etc., are also in progress. The object of this survey is to isolate the field management and environmental factors which affect the yield of tea and to estimate their individual contributions to throw light on the future course of research for increasing the yield of tea.

Touring and Advisory

The Statistician and two staff members visited the Indian Institute of Technology, Kanpur, once in connection with the statistical analyses of data from long-term and complex experiments on the IBM 7044 electronic computer. The Statistician also visited the Directorate of Agriculture, Lucknow, the Indian Statistical Institute and Information Processing Centre, Calcutta, during the year. He also paid three visits to Bokahola T. E. in connection with the Uniformity Trial which was also visited weekly by three staff members.

Library and Publication Department

LIBRARY

General

Four new journals were added to the subscription list and two were discontinued. As in the previous years, subscriptions to the foreign scientific journals increased this year.

Reorganisation

One temporary typist was engaged for six months to type the Classified Catalogue Cards. The authors' cards and other index cards were hand written. Reorganisation of library to improve reader service has been undertaken within the available resources.

Four study cubicles for research workers have been constructed inside the previous main office hall. The library staff have been shifted to the hall permanently, thus permitting the reorganisation of the stack room, with addition of ten new steel racks. Spraying and varnishing of books have been carried out as usual. Cataloguing of books and indexing of articles are continuing.

Book binding

1312 Journal Volumes were bound during the year. Some old volumes of journals and books were rebound.

Loan Service

Under and Post-graduate students of the Tea Science Department, Research scholars of Assam Agricultural University and Scientists of Regional Research Laboratory, Jorhat used the library. The Tocklai trainees and the staff continued to utilise the library. T.R.A. members used the library for references and information.

Open Day

On the occasion of the 25th anniversery on India's independence and silver jubilee, the library was opened to general public on the 17th August 1972. Several hundred visitors including the students of local schools and colleges visited the library. A new brochure on Tocklai was printed and distributed gratis to mark the occasion.

Book Preservation

A new book-preservative "Ballistol" and a leather-preservative, "Kasto", sent by a commercial firm were tried. "Ballistol" was effective against booklice and silver-fishes.

Varnishing of the spine and top portions of the journal volumes with a mixture of Gammexane and creosote was more effective against rodents than Paris-green, as was previously applied.

Library Statistics

Books added during the year	112
Periodicals and Journals	1694
Pamphelets & Bulletins	668
Photo copies	5
Reprints	2
Maps	1
Microfilm	2
Publications consulted in Library	1440
Publications issued to Departments	765

PUBLICATIONS

The activities of the publication unit continued to increase during the year. The correspondence on Tocklai publications from members and non-members of T. R. A. increased considerably due to increase in subscribers.

The following publications were issued from Tocklai :

(1) **Two & A Bud** Vol. 19, Nos. 1 and 2.

(2) **Tea Encyclopaedia Serial**
No. 62/1 Nickel Choloride and Copper fungicide Spraying against Blister Blight Amendment Slip.

(3) **Advisory Leaflet**
No. 6 Potash Manuring in West Bengal By W. J. Grice.

(4) **Advisory Bulletins**
No. 4 Planting Calendar for the Dooars & Terai- By W. J. Grice and S. Basu.

No. 5 — Some Efficient & Economical Herbicide Cocktails for use in Tea By S. K. Dutta & B. C. Barbora and its addendum by Director.

(5) **Miscellaneous Reports**

T.R.A. Annual Scientific Report for 1971-72.

Memorandum No. 29 'Some Common Weeds of the Tea Estates in North-East India' By A. C. Dutta.

Engineering Development Department's Report for the Quarter ending 30th June 1972 (Circulation restricted).

Engineering Development Department Report for Quarter ending 30th September 1972 (Circulation restricted).

Engineering Development Department Report for Quarter ending 31st December 1972 (Circulation restricted).

Proceedings of the Twentyfifth Tocklai Conference held on 16th, 17th and 18th November, 1971.

Amendment Slip for I. T. A. Memorandum No. 26 "Diseases of tea and associated crops in north-east India."

Amendment Slip for Wall-chart—Recommendations for control of Pests and Diseases of tea & shade trees with power Sprayers—March, 1972.

Appendix-A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES
BY
THE ADVISORY DEPARTMENT

SOUTH BANK, ASSAM

Project	Site	Index	Year of starting
NPK Manuring	Murmuria	AS 11*	1956
	Sycotta	AS 34*	1960
	Katonibari	AS 44*	1963
	Hunwal	AS 51*	1964
	Dirok	AS 63*	1965
	Ghillidary	AS 88*	1968
	Hunwal	AS 92*	1969
	Haroocharai	AS 98*	1970
NPK Manuring with Gramoxone	Doom Dooma Tea Co.	AS 95A*	1969
	,, ,,	AS 95B*	1969
Nitrogenous fertilizer	Sycotta	AS 56*	1964
	Sagmootea	AS 62*	1965
	Joonktollee	AS 64*	1966
	Furkating	AS 69*	1966
	Halmirah	AS 71*	1966
	Joonktollee	AS 82*	1967
	Haroocharai	AS 99*	1970
Nitrogenous fertilizer Vs liming	Cinnamara	AS 77*	1966
	Meleng	AS 78*	1966
Pruning	Dufflating	AS 84*	1957
	Margherita	AS 97*	1969
Plucking	Cinnamara	AS 100*	1971
Jat and Clonal Trial	Tyroon	AS 89	1968
	Tyroon	AS 96	1969

NORTH BANK, ASSAM

Project	Site	Index	Year of starting
NPK Manuring	Ananda	AN 93*	1969
Nitrogenous fertilizer	Nahorhabi	AN 59*	1964
	Hatigar	AN 91*	1969
	Ananda	AN 94*	1969
Nitrogenous fertilizer Vs Liming	Gingia	AN 80*	1966
High Potash application	Tinkharia	--	1967
	Dufflaghur	--	1967
Pruning	Phulbari	AN 58*	1964
	Kolony	AN 76*	1966
Plucking	Tarajuli	AN 101	1972
	Dhulapadung	AN 102	1972
Irrigation	Sessa	AN 61*	1965
Cultivation and Weed Control	Halem	AN 31*	1960

CACHAR, ASSAM

Project	Site	Index	Year of starting
Rehabilitation of land	Koomber	C 25*	1964
NPK Manuring	Isa Bheel	C 26*	1966
	Hattikhira	C 27*	1966
	Longai	C 28*	1966
Nitrogenous fertilizer	Pallorbund	C 29*	1966
	Dewan	C 30*	1966
Phosphatic fertilizer	Chandighat	C 37*	1972
Pruning	Pallorbund	C 33*	1967
	Derby	C 35*	1968
Shade and Manuring	Koomber	C 36*	1968
Soil Climatological Survey	Coombergram	C 20	1962

DOOARS AND TERAI, WEST BENGAL

Project	Site	Index	Year of starting
Rehabilitation of land	Bhogotpore	D 27	1964
	Grassmore	D 28	1964
Nitrogenous fertilizer	Baradighi	D 33	1966
Pruning	Chuapara	D 2*	1955
	Baradighi	D 1*	1959
	Sam Sing	D 34*	1966
Irrigation	Gopalpur	D 35*	1966
	Ranicherra	D 36*	1968
	Tirrihannah	TR 1*	1968
Cultivation and Weed Control	Chuapara	D 12	1970
Soil Climatological Survey	Nya Sylee	D 24	1962
Shade	Nya Sylee	D 9	1958
Infilling	Jainti	D 41	1969
	Fagu	D 37	1969
	Hilla	D 39	1969
	Dem Dima	D 40	1969
	Sahabad	TR 4	1969
	Moburgong & Gulma	TR 3	1969
Rejuvenation Trial	Dalgaon	D 43	1972
	Matelli	D 44	1972
	Kilcott	D 45	1972
	Rydak	D 46	1972
	Gungaram	TR 5	1972
	Kumlai	D 47	1972

DARJEELING, WEST BENGAL

Project	Site	Index	Year of starting
NPK Manuring	Tumsong	Dj 22*	1965
	Sungma	Dj 23*	1965
Nitrogenous fertilizer	Lingia	Dj 29	1967
	Singell	Dj 26*	—
	Marybong	Dj 28*	—
High level potash	Marybong	*	1970
Pruning	Lingia	Dj 21*	1963
	Phoobsering	Dj 24*	1965
	Goomtee	Dj 25*	1966
	Margaret's Hope	Dj 27	1966
Plucking	Mim	Dj 18*	1961
Soil Climatological Survey	Nagri Farm	Dj 19	1961

* Experiments disbanded end 1972

Appendix-B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES
BY
THE OTHER DEPARTMENTS

BOTANY DEPARTMENT

Sl No.	Experiment	Location of Estate	Site (T. E.)	Index No.	Year starting
1.	Trial of biclonal seed stock	South Bank, Assam	Kakajan	AS 206	1966
2.	,,	North Bank, Assam	Nahorani	AN 202	1963
3.	,,	,,	Sonabheel	AN 203	1964
4.	,,	Dooars, West Bengal	Bhatkawa	D 201	1962
5.	,,	,,	Bhatkawa	D 206	1965
6.	,,	,,	Hantapara	D 202	1964
7.	,,	,,	Meenglass	D 203	1964
8.	,,	,,	Rydak	D 205	1965
9.	,,	Terai, West Bengal	Hansqua	TR 200	1968
10.	,,	Darjeeling, West Bengal	Mim	Dj 200	1961
11.	,,	,,	Ging	Dj 201	1965
12.	Observation plots of biclonal progenies	South Bank, Assam	Abhoyjan		1969
13.	,,	,,	Duklingia		1963
14.	,,	North Bank, Assam	Nonaipara		1966
15.	,,	Dooars, West Bengal	Meenglass		1968
16.	,,	Sikim	Kewzing		1969
17.	Plucking experiment	South Bank, Assam	Duklingia	AS 208	1971

ENTOMOLOGY DEPARTMENT

Sl. No.	Experiment	Location of Estate	Site (T.E.)	Index No.	Year started
1.	Abundance of pink and purple mite on young and mature tea.	South Bank, Assam	Sycotta	N 7	1971
	Palliative mite trial (Red spider)	,,		—	
	Red rust trial			—	
2.	Distribution of pink and purple mite under shaded condition	,,	Socklatinga	N 7	1971
	Palliative mite trial (Red spider)			—	
3.	Abundance of pink and purple mite on pruned and skiffed tea	,,	Bokahola & Nagadhoolie	N 7	1971 1972
	Black rot trial	,,	,,	—	1971

Sl. No.	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
4.	Distribution of red spider, spider, scarlet, pink and purple mite on clones and jats	South Bank, Assam	Deha	N 7	1971
	Prophylactic mite trial (Red spider)	,,	,,	—	1972
5.	Incidence of scarlet, pink and purple mite on clones and jats	Cachar, Assam	Longai	N 7	1971
6.	Abundance of scarlet, pink and purple mite on pruned, light skiffed and deep skiffed tea.	,,	Longai	N 7	1971
7.	Susceptibility of pruned and deep skiffed tea to scarlet, pink and purple mite	,,	Hattikhira	N 7	1971
8.	Pink and purple mite on purned and skiffed tea	Dooars, W. Bengal	Ranicherra	N 7	1971
9.	Distribution of pink and purple mite under shaded condition	,,	,,	N 7	1971
10.	Relative susceptibility of clones and jats to pink and purple mite.	,,	,,	N 7	1971
11.	Distribution of pink and purple mite under shaded condition	Darjeeling, W. Bengal	Nagri	N 7	1971
12.	Pink and purple mite on pruned and skiffed tea	,,	Nagri & Tukdah	N 7	1971
13.	Red spider (Palliative)	South Bank	Deha		1972
14.	,, ,, ,,	,, ,,	Hoolungoorie		1972
15.	,, ,, ,,	,, ,,	Cinnamara		1973
16.	,, ,, ,,	Cachar	Serispore		1973
17.	Scarlet mite	South Bank	Socklatinga		1972
18.	,, ,, ,,	Cachar	Burnie Braes		1972
19.	Scale insect	Darjeeling	Happy Valley		1972
20.	Looper Caterpillar	South Bank	Nagadhoolie		1972
21.	Termite trial	North Bank	Tarajulie		1973
22.	Red borer	,,	Durrung		1973
23.	Termite trial	South Bank	Pabhojan		1973
24.	Black rot	,,	Nagadhoolie		1972
25.	Red rust	,,	Deha		1972
26.	Blister blight	Darjeeling	Bannockburn		1972
27.	,, ,,	,,	Phoobsering		1972

MYCOLOGY

Sl No.	Experiment	Location of site	Site (T. E.)	Index No.	Year started
1.	To compare the effect of application of a standard copper formulation in 4 rounds at different time interval.	South Bank	Konikar Dallim	MR 009	1972
			Deha	MR 010	
2.	NPK manuring and its effect on the incidence of thorny stem blight (Collaboration : Darjeeling Advisory Branch)	Darjeeling, West Bengal	Sungma	MC 004	1966
3.	High level potash and thorny stem blight	Darjeeling, West Bengal	Marrybong	MC 005	1972
4.	Application of a systemic fungicide against thorny stem blight	,, ,,	Balasun	MC 005	1970
5.	Screening of chemicals against black rot.	North Bank	Ananda	MB 009	1972
6.	Efficiency of spraying against black rot	,, ,,	Ghoirallie	MB 002	1968
7.	Control against purple root	,, ,,	Baghmari	MP 001	1965

STATISTICS DEPARTMENT

Sl. No.	Project	Site (T. E.)	Index No.	Year started
1.	Uniformity trial	Bokahola (South Bank, Assam)	-	1963
2.	Uniformity trial	Nagri Farm (Darjeeling, W. Bengal)	-	1964
3.	Long term defoliation experiment	Nya Sylee (Dooars, West Bengal)	-	1963
		Bhogotpore (,, ,,)		1963
		Jiti (,, ,,)		1963
		Hope (,, ,,)		1963
		Kurti (,, ,,)	-	1963

ENGINEERING RESEARCH & DEVELOPMENT DEPARTMENT

Sl. No.	Experiment	Index No.	Location of estate	Site Tea Estate
1.	48" Disc Roller	E. 2	South Bank, Assam	Heelcakah
2.	Leaf Sizer Attachment	E. 2	South Bank, Assam	Cinnamara
3.	-do-	E. 2	Dooars, W. Bengal	Meenglass
4.	Manual Plucking Aid	E. 8.	South Bank, Assam	Borbhetta

Appendix-C

Published papers and papers in the Press

1. Banerjee, B. (1972) Eclosion and oviposition rhythms of *Andraca bipunctata* Wlk (Bombycidae : Lepidoptera) with a model for determining theoretical moth densities from eclosion rate. *Indian J. Ent.*, 33 :4; 411-418.

(Abs. Eclosion and oviposition of the moth *Andraca bipunctata* follow specific rhythmic patterns with fixed time for activity during a 24-hour cycle. Moths emerge throughout the night, but with high frequency at both dawn and dusk. Oviposition is at maximum between 20.47 hr Solar Time. A common feature in both the behaviour patterns is their complete absence during the day-light hours. Eclosion and oviposition follow daily rhythmic pattern irrespective of fluctuations in light and climatic factors in different seasons. It is suggested that these rhythms are responses to an endogenous bioligical clock. The model for determining theoretical moth densities appropriately predicts the moth density for any sampling day, provided eclosion is continuous.)

2. Banerjee, B. (1972) New concepts in tea pest control : objective and perspective. *Pl. Jr. agric.*, 50:1; 9-10.

(Abs. The ecological problems associated with long term control of tea pests are discussed. It is suggested that by refining the techniques of pest management, better and efficient means for controlling pests can be developed.)

3. Bezbaruah, H. P. & Gogoi, S. C. (1972) An interspecific hybrid between tea (*Camellia sinensis* L.) and *C. japonica* L. *Proc. Indian Acad. Sci.*, 76 : 219-220.

(Abs. A single seedling produced by crossing a tetraploid tea plant *Camellia sinensis* (2n=60) with *C. japonica* (2n = 30) resembled some of the "China-hybrids" and Gambod varieties of tea in cultivation. This suggests that natural hybrids between the two species must have occurred in the past).

4. Ullah, M. R. (1972.) A simplified Spectro photometric method for measuring Theaflavins and Thearubigins in Black Tea Liquors. *Curr. Sci.*, 41 (11) 422.

(Abs. The two groups of coloured substances, theaflavins (TF) and thearubigins (TR) of black tea are considered to be responsible for the colour, strength, briskness and 'quality' of tea liquors. A knowledge of their quantities in tea liquors therefore, aids in the assessment of black teas. The method for their quantitative estimation involves the partition of the tea liquor into organic (TF) and aqueous (TR) phases and use of sodium bicarbonate for removing left over TR from the organic phase. Sodium bicarbonate being unstable in a tropical climate, have deleterious effects on the colours and stands in the way of the reproduction of results. In the simplified method, the TF and TR are together measured directly in the tea liquor itself. The TF alone is measured in the ethyl acetate extract of the liquor in which the TR are fixed with disodium hydrogen phosphate. The method serves the purpose for routine analysis of black tea samples with ease of operation).

5. Banerjee, B. Phenology and spatial distribution of the mounds of *Odontotermes redemanni* (Wasmann). *Ins. Soc. Paris.* (In the press)

6. Banerjee, B. Some questions in population ecology. In *Series Biomathematics* (In the press).

7. Banerjee, B. The distribution and population cycle of the red spider mite, *Oligonychus coffeae* (Nietner) on tea. *Bull. Ent. Res.* (In the press).

8. Banerjee, B. The Breeding biology of *Polydesmus angustus* Latzel Norsk. *Ent. Tids.* (In the press)

9. Barua, D. N. & Saikia, L. R. (1972) Stock-scion compatibility in tea. *J. hort. Sci.* (In the Press)

10. Barua, D. N. (1972) World Population and Food Supply. *J. Assam Sci. Soc.*, XV, 115-124.

11. Barua, D. N. (1972) Tea (*Camellia sinensis* L.) For F. A. O. Hand Book on Plant Introduction (In the Press).

12. Biswas, Ajit K., Sarkar, Arup R. & Biswas, Asim K. Biological and Chemical Factors Affecting the Valuations of North-East Indian Plains Teas. III.- Statistical evaluation of the biochemical constituents and their effects on colour, brightness and strength of black teas. *J. Sci. Fd. Agric.* (In the press)

13. Hadfield, W. Shade in N. E. Indian Tea plantations. I. The shade pattern. *J. appl. Ecol.* (In the press)

14. Hadfield, W. Shade in N. E. Indian Tea plantations. II. Foliar illumination and canopy characteristics. *J. appl. Ecol.* (In the press)

15. Hadfield, W. Shade in N. E. Indian Tea plantations III. Leaf temperatures of tea plants in N. E. India. *J. appl. Ecol.* (In the press)

Appendix-D

Summary of meteorological observations during 1972

Table 1. Tocklai (Mid Assam)

Latitude : 26°47'N Longitude : 94°12' E Altitude : 96.5 metres a.m.s.l.

Month 1972	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly Evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	monthly in mm	Day with 0.03 mm and above		Depth 5 cm	15 cm	30 cm	Open pan in mm	Penr in m
January	22.6	11.8	17.2	24.5	8.5	35.6	5	6.0	18.7	18.6	19.4	36.7	60
	(22.4)	(9.3)	(15.8)			(21.5)	(5)	(5.8)	(18.8)	(18.2)	(18.9)		
February	23.1	12.7	17.9	26.8	7.5	40.3	10	6.1	19.5	19.2	19.8	48.5	81
	(21.1)	(11.8)	(18.0)			(32.3)	(7)	(6.2)	(20.5)	(19.8)	(20.2)		
March	27.1	16.8	22.0	31.5	13.3	70.7	10	7.1	23.8	23.2	23.3	85.8	1,27
	(27.5)	(15.4)	(21.4)			(81.4)	(11)	(6.6)	(24.0)	(23.0)	(23.0)		
April	25.4	18.8	22.1	31.0	15.8	3,39.8	23	4.8	24.8	24.4	24.6	77.4	1,20
	(28.7)	(18.9)	(23.8)			(1,87.8)	(16)	(5.9)	(27.0)	(25.8)	(25.6)		
May	28.7	22.1	25.4	33.8	18.5	2,95.1	24	3.9	28.0	27.2	27.2	82.6	1,35
	(29.9)	(21.8)	(25.8)			(2,83.4)	(20)	(5.0)	(28.7)	(27.7)	(27.6)		
June	31.6	24.6	28.1	35.6	22.1	4,76.4	21	4.9	30.6	30.0	29.8	1,03.3	1,54
	(31.5)	(24.1)	(27.8)			(3,27.7)	(23)	(4.5)	(30.6)	(29.6)	(29.4)		
July	32.2	25.6	28.9	36.1	23.8	3,26.7	23	3.6	31.6	31.6	31.0	1,03.6	1,46
	(32.2)	(24.5)	(28.4)			(3,84.6)	(25)	(4.7)	(31.4)	(30.6)	(30.4)		
August	32.8	25.2	29.0	35.3	22.6	4,06.8	19	6.8	32.0	31.6	31.4	1,14.2	1,79
	(32.0)	(24.5)	(28.2)			(3,41.6)	(23)	(5.0)	(31.4)	(30.6)	(30.5)		
September	30.4	24.1	27.2	34.0	22.8	2,07.6	21	4.8	30.0	29.8	29.9	70.8	1,29
	(31.3)	(23.8)	(27.5)			(2,53.8)	(19)	(5.0)	(31.0)	(30.2)	(30.2)		
October	29.5	21.3	25.4	32.6	17.7	1,32.6	9	6.1	27.9	27.9	28.2	68.6	1,19
	(29.3)	(20.9)	(25.1)			(1,17.6)	(12)	(5.6)	(28.4)	(27.8)	(28.2)		
November	27.1	15.2	21.2	29.1	12.4	2.6	2	7.1	23.4	23.4	24.2	48.0	83
	(26.2)	(15.1)	(20.6)			(27.8)	(4)	(6.1)	(24.0)	(23.6)	(24.5)		
December	23.9	11.3	17.6	28.8	8.3	11.6	3	6.4	19.1	19.3	20.4	35.0	62
	(23.4)	(10.6)	(17.0)			(10.5)	(3)	(6.0)	(19.9)	(19.6)	(20.6)		

Per cent Relative humidity

Table 1(a). Tocklai

Hours of observations I. S. T.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0613	94	92	89	92	92	91	93	91	93	94	95	95
	(97)	(95)	(92)	(91)	(93)	(93)	(93)	(94)	(95)	(97)	(97)	(97)
1313	61	55	55	72	73	72	73	68	74	70	59	55
	(57)	(54)	(54)	(62)	(71)	(75)	(75)	(75)	(74)	(72)	(64)	(60)

Note : (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Summary of meteorological observations during 1972

Table 2. Silcoorie (Cachar)

titude : 24°50' N Longitude : 92°48' E Altitude : 39.6 metres a.m.s.l.

	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
									Depth				
	Mean max.	Mean min.	Mean	Highest	Lowest	monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
ry	26.6	11.9	19.2	28.1	8.9	0.0	0	8.0	22.1	21.4	22.5	60.5	81.2
	(25.9)	(10.9)	(18.4)			(21.5)	(2)	(8.0)	(21.3)	(20.6)	(21.4)		
ıary	26.0	11.9	19.0	29.7	7.5	50.5	3	8.0	22.0	21.0	22.2	65.0	1,00.5
	(27.5)	(12.9)	(20.2)			(52.6)	(4)	(8.1)	(23.2)	(22.0)	(22.4)		
h	31.3	15.5	23.4	35.1	9.4	88.9	8	8.7	27.2	25.7	26.2	?	1,52.5
	(30.7)	(16.5)	(23.6)			(1,05.9)	(7)	(7.9)	(26.9)	(25.4)	(25.4)		
	29.9	19.2	24.6	34.6	16.4	4,54.7	23	7.2	27.8	26.6	27.0	?	1,53.9
	(32.0)	(20.5)	(26.2)			(2,24.4)	(13)	(7.7)	(29.5)	(28.0)	(28.0)		
	31.5	22.0	26.8	35.1	18.3	3,89.1	18	7.1	30.5	29.0	29.0	1,57.1	1,80.8
	(32.0)	(22.8)	(27.4)			(3,71.1)	(19)	(6.6)	(30.6)	(29.4)	(29.4)		
	31.2	23.5	27.4	35.9	21.4	6,69.6	22	1.8	30.8	29.8	29.6	1,47.9	1,47.6
	(31.6)	(24.5)	(28.0)			(5,89.6)	(25)	(4.1)	(30.6)	(29.6)	(29.6)		
	32.5	24.8	28.6	37.3	23.3	4,84.6	28	4.5	32.0	30.9	31.0	1,09.6	1,54.6
	(32.1)	(25.0)	(28.6)			(5,33.8)	(27)	(4.4)	(31.4)	(30.4)	(30.4)		
st	32.9	24.0	28.4	35.1	22.9	4,21.5	22	5.3	32.2	31.0	31.0	1,20.3	1,60.3
	(32.1)	(24.9)	(28.5)			(4,40.2)	(25)	(1.7)	(31.4)	(30.6)	(30.6)		
mber	32.7	23.7	28.2	37.1	21.7	2,01.4	15	6.7	32.0	30.9	31.0	1,23.7	1,54.0
	(32.3)	(24.5)	(28.4)			(3,46.6)	(18)	(5.7)	(31.2)	(30.4)	(30.5)		
ber	32.4	21.8	27.1	35.1	18.3	1,81.6	9	8.3	30.1	29.3	29.6	1,00.5	1,48.3
	(31.1)	(22.4)	(26.8)			(2,23.3)	(11)	(6.4)	(29.4)	(28.8)	(29.0)		
mber	30.6	18.2	24.4	32.5	14.1	0.0	0	8.1	27.6	26.7	27.4	85.6	1,11.7
	(29.1)	(16.9)	(23.0)			(22.9)	(2)	(7.9)	(25.8)	(25.4)	(26.0)		
mber	27.8	11.9	19.8	32.1	7.7	0.0	0	8.5	23.7	22.9	24.3	92.4	84.6
	(26.9)	(12.5)	(19.7)			(7.3)	(1)	(8.0)	(22.7)	(22.2)	(23.0)		

Per cent Relative humidity

Table 2(a). Tocklai

Hours of rvations . S. T.	January	February	March	April	May	June	July	August	September	October	November	December
0619	99	99	94	92	90	93	98	95	92	94	97	99
	(98)	(96)	(93)	(91)	(91)	(95)	(95)	(96)	(95)	(96)	(97)	(98)
1319	49	44	41	63	67	76	79	73	69	63	55	46
	(46)	(43)	(43)	(55)	(67)	(76)	(75)	(74)	(71)	(68)	(56)	(49)

Note : (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.
(iv) ? indicates data not available.

Summary of meteorological observations during 1972

Table 3. Nagrakata (Dooars)

Latitude : 26°54′ N Longitude : 88°55′ E Altitude : 228.6 metres a.m.s.l.

Month 1972	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
									Depth				
	Mean max.	Mean min.	Mean	Highest	Lowest	monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	24.1	11.6	18.0	25.6	10.0	6.6	2	7.5	19.2	19.6	20.2	80.0	71.0
	(23.6)	(10.3)	(17.0)			(12.2)	(2)	(7.9)	(18.1)	(18.2)	(19.5)		
February	22.8	11.8	17.3	27.6	7.0	31.0	6	5.8	18.9	19.4	19.8	72.0	82.9
	(25.6)	(12.9)	(19.2)			(19.6)	(3)	(7.7)	(20.2)	(19.8)	(20.6)		
March	30.0	17.1	23.6	34.4	12.1	15.2	4	7.6	25.7	24.8	24.3	1,52.4	1,45.8
	(29.2)	(16.3)	(22.8)			(46.0)	(5)	(7.7)	(23.8)	(23.9)	(23.6)		
April	29.8	19.2	24.5	32.0	14.6	1,99.1	13	7.7	26.9	26.6	26.2	1,52.9	1,61.4
	(31.1)	(20.0)	(25.6)			(1,40.2)	(11)	(7.2)	(26.8)	(26.2)	(26.4)		
May	30.2	22.5	26.4	33.0	19.0	7,15.8	22	6.1	28.4	27.8	27.9	1,49.6	1,65.9
	(30.9)	(21.6)	(26.2)			(3,00.2)	(19)	(6.7)	(28.4)	(27.6)	(27.9)		
June	30.5	23.3	26.9	35.0	21.0	8,88.8	22	4.3	28.7	28.0	28.8	1,06.7	1,44.9
	(30.3)	(23.3)	(26.8)			(8,89.1)	(26)	(3.8)	(28.6)	(28.0)	(28.4)		
July	29.9	23.2	27.0	35.4	22.5	15,63.3	28	2.8	28.5	28.0	28.8	1,03.9	1,24.9
	(30.1)	(23.8)	(27.1)			(10,44.0)	(27)	(3.5)	(29.1)	(28.3)	(28.7)		
August	31.1	23.8	27.4	33.8	22.0	8,79.5	24	1.8	28.8	28.6	28.1	1,12.5	1,50.4
	(30.5)	(23.7)	(27.1)			(7,67.3)	(28)	(4.0)	(29.2)	(28.8)	(29.0)		
September	30.7	22.6	26.6	34.4	19.1	6,98.9	19	5.0	28.0	28.3	27.2	1,07.0	1,28.9
	(30.6)	(22.9)	(26.8)			(5,14.3)	(22)	(5.2)	(29.0)	(28.9)	(28.9)		
October	29.5	20.2	24.8	33.5	17.5	2,41.5	13	6.5	26.8	27.3	27.4	99.6	1,20.9
	(29.8)	(19.3)	(24.6)			(1,97.6)	(10)	(7.9)	(26.8)	(27.2)	(27.2)		
November	27.6	15.0	21.3	30.0	12.5	8.2	2	9.1	23.0	23.8	24.2	89.6	1,00.0
	(27.2)	(14.6)	(20.9)			(14.5)	(3)	(8.6)	(22.6)	(22.9)	(24.0)		
December	24.9	11.6	18.2	28.4	8.4	0.0	0	8.1	19.7	20.2	21.4	68.1	71.0
	(24.9)	(11.5)	(18.2)			(1.4)	(1)	(8.5)	(19.5)	(19.9)	(21.0)		

Per cent Relative humidity

Table 3(a). Nagrakata

Hours of observations I. S. T.	January	February	March	April	May	June	July	August	September	October	November	December
0634	89	86	74	85	98	94	97	92	92	89	82	84
	(84)	(81)	(74)	(76)	(86)	(95)	(96)	(96)	(95)	(88)	(86)	(95)
1334	56	55	40	56	69	77	81	78	72	67	52	50
	(51)	(49)	(46)	(53)	(69)	(83)	(84)	(82)	(78)	(66)	(58)	(53)

Note : (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Summary of meteorological observations during 1972

Table 4. Nagri Farm (Darjeeling)

Latitude : 26°55' N Longitude : 88°12' E Altitude : 1,158.2 metres a.m.s.l.

Month 1972	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
									Depth				
	Mean max.	Mean min.	Mean	Highest	Lowest	monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	15.8	8.3	12.0	18.6	5.7	33.0	2	5.5	14.2	12.4	14.8	42.3	54.7
	(15.2)	(7.8)	(11.5)			(18.3)	(3)	(6.4)	(13.2)	(12.5)	(14.0)		
February	14.3	7.9	11.1	19.9	4.5	39.9	7	3.9	12.8	11.4	13.5	40.5	69.3
	(16.8)	(9.6)	(13.2)			(16.4)	(3)	(6.1)	(14.8)	(13.6)	(14.6)		
March	21.9	13.5	17.7	25.4	10.0	12.7	2	5.8	18.7	16.2	17.3	89.1	1,13.6
	(21.0)	(12.9)	(17.0)			(57.6)	(5)	(6.8)	(18.9)	(17.3)	(17.6)		
April	23.1	14.8	19.0	25.4	10.6	1,50.0	10	3.0	21.0	18.8	19.9	98.0	1,08.8
	(23.5)	(15.7)	(19.6)			(93.8)	(10)	(5.8)	(21.7)	(20.1)	(20.2)		
May	23.9	17.8	20.8	25.8	15.0	1,64.4	18	4.7	23.9	21.3	22.2	83.7	1.30.0
	(23.8)	(17.2)	(20.5)			(2,03.0)	(19)	(5.3)	(23.5)	(22.9)	(22.0)		
June	24.5	18.9	21.7	26.8	17.0	2,87.3	24	3.1	24.8	22.5	23.5	58.9	1,15.0
	(24.0)	(18.3)	(21.4)			(4,30.7)	(25)	(3.0)	(23.5)	(23.2)	(23.3)		
July	24.5	19.8	22.2	28.8	18.3	6,23.6	29	1.6	21.6	22.8	24.1	56.5	1.03.6
	(24.1)	(19.3)	(21.7)			(6,71.7)	(27)	(2.4)	(24.9)	(23.6)	(23.8)		
August	25.1	19.0	22.0	27.9	17.8	3,57.2	24	4.6	25.0	23.1	24.4	80.8	1,27.3
	(24.6)	(19.1)	(21.8)			(4,74.0)	(26)	(3.1)	(25.3)	(23.8)	(24.2)		
September	24.5	17.6	21.0	29.3	15.5	6,07.3	17	3.9	23.5	21.7	23.1	63.0	1.02.6
	(24.4)	(18.3)	(21.4)			(3,03.7)	(20)	(4.0)	(24.4)	(23.3)	(23.8)		
October	23.1	15.6	19.4	27.3	11.4	38.8	7	5.5	22.1	20.2	21.9	58.5	97.7
	(23.2)	(15.6)	(19.4)			(1,35.3)	(8)	(6.8)	(22.1)	(21.1)	(21.8)		
November	21.0	12.7	16.8	23.6	11.2	5.9	2	7.7	17.8	16.4	18.6	58.5	83.7
	(20.0)	(11.7)	(15.8)			(11.8)	(3)	(7.2)	(18.0)	(17.3)	(18.7)		
December	17.5	9.5	13.5	21.6	6.6	0.0	0	6.9	14.4	13.6	15.7	49.7	60.1
	(17.7)	(9.3)	(13.5)			(2.6)	(1)	(7.0)	(14.8)	(14.0)	(15.7)		

Per cent Relative humidity

Table 4(a). Nagri Farm

Hours of observations I. S. T.	January	February	March	April	May	June	July	August	September	October	November	December
0637	73	71	65	73	84	90	96	89	87	78	65	66
	(71)	(70)	(64)	(68)	(80)	(92)	(94)	(94)	(89)	(76)	(68)	(69)
1337	72	67	57	67	83	86	89	81	86	81	60	67
	(72)	(65)	(61)	(67)	(82)	(89)	(90)	(88)	(86)	(79)	(72)	(70)

Note : (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.